DOCUMENT RESUME

ED 324 396 CE 053 934

TITLE Marine Engine Technology. Instructor's Guide.
INSTITUTION Lake Michigan Coll., Benton Harbor.; Moraine Park Technical Coll., Fond du Lac, WI.; Seminole Community Coll., Sanford, Fla.
SPONS AGENCY Sears-Roebuck Foundation, Skokie, Ill.
PUB DATE 89
NOTE 488p.
PUB TYPE Guides - Classroom Use - Guides (For Teachers) (052)

EDRS PRICE MF02/PC20 Plus Postage.
DESCRIPTORS *Competency Based Education; *Marine Technicians; Mechanical Equipment; Mechanical Skills; *Power Technology; *Small Engine Mechanics; Vocational Education
IDENTIFIERS *Outboard Motors

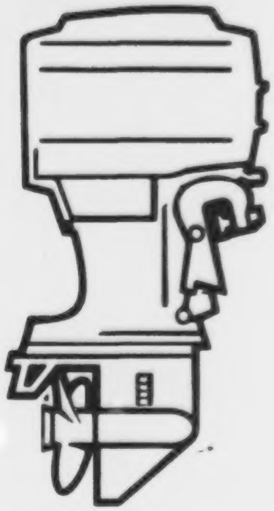
ABSTRACT

This instructor's manual covers 20 competency-based instructional units designed to prepare entry-level outboard marine technicians. The first section explains how to use the materials and lists the units and the modules that constitute each. The second section lists the competencies taught in the course. The third section suggests instructional hours for each module. Section 4 lists 17 print references, 11 audiovisual materials, 21 information sheets that appear in the document, 115 pieces of suggested equipment, and 60 pieces of equipment that should constitute a tool kit for every two students. Section 5 lists 10 objectives for an orientation session in marine mechanics. Section 6 contains blank student performance checklists that may be copied. The 20 instructional units cover the following subjects: safety; tools; hardware; service documentation; boats, boat towing, and boat handling; gasoline engines; introduction to sterndrive systems; lubricants; electricity; painting; welding; outboard ignition systems; outboard fuel and oil systems; outboard powerhead electrical and starting systems; outboard powerhead; outboard midsection; gear cases; outboard controls; rigging; and job-seeking skills. The modules that comprise each of these units typically contain a competency statement, a set of instructional objectives, a suggested series of learning activities, checklists that can be used as aids for evaluating students' performance, a master copy of multiple choice tests, and an information sheet. (CML)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

ED324396

MARINE ENGINE TECHNOLOGY



INSTRUCTOR'S GUIDE

MORAINE PARK TECHNICAL COLLEGE
SEMINOLE COMMUNITY COLLEGE
LAKE MICHIGAN COLLEGE

CE053934

U.S. DEPARTMENT OF EDUCATION
Office of Educational Research and Improvement
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

☑ This document has been reproduced as received from the person or organization originating it

☐ Minor changes have been made to improve reproduction quality

- Points of view or opinions stated in this document do not necessarily represent official OERI position or policy

1989

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY
W. Weirick
J. Neill
S. Tesinsky
TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

TABLE OF CONTENTS

ACKNOWLEDGEMENTS 2

SUGGESTED USE OF THE MARINE ENGINE TECHNOLOGY INSTRUCTOR'S GUIDE 3

LIST OF UNITS AND MODULES 5

LIST OF COMPETENCIES 7

SUGGESTED ASSIGNMENT OF INSTRUCTIONAL HOURS 10

REFERENCES 13

LIST OF A/V MATERIALS 16

LIST OF INFORMATION SHEETS 18

LIST OF SUGGESTED EQUIPMENT 19
    SHOP TOOLS 19
    STUDENT TOOL KIT 22

OBJECTIVES FOR STUDENT ORIENTATION 24

BLANK FORMS 26
    PERFORMANCE CHECKLIST 27
    MASTER CHECKLIST 28

ACKNOWLEDGEMENTS

The Marine Mechanics Instructor Guide was developed as a project funded in part by the Sears Roebuck Foundation Partnership Development Fund Keep America Working Project. Additional funding and support were provided by Seminole Community College in Sanford, Florida; Lake Michigan College in Benton Harbor, Michigan; and Moraine Park Technical College in Fond du Lac, Wisconsin.

The following individuals are recognized for their part in making the project possible:

Les Barkley
Marine Mechanics Technology Program Manager
Seminole Community College

Eugene Beck
Vice President, Economic/Community Services
Moraine Park Technical College

Patricia Hall
Dean of Occupational Studies
Lake Michigan College

Larry Hutt
Marine Mechanics Technology Instructor
Semninole Community College

Ed Lojko, Jr.
Project Curriculum Developer
Sanford, Florida

Judith W. Neill
Associate Dean, Instructional Design and Development
Moraine Park Technical College

Donna Nickel
Director of Curriculum Development
Seminole Community College

Garry Simms
Marine Mechanics Technology Instructor
Seminole Community College

Stanley J. Spanbauer (Project Evaluator)
President
Fox Valley Technical College
Appleton, Wisconsin

Suzanne Tesinsky
Dean, Vocational Education
Seminole Community College

SUGGESTED USE OF THE MARINE ENGINE TECHNOLOGY INSTRUCTOR'S GUIDE

The Marine Engine Technology Instructor's Guide is organized into sections based on Units of Instruction. The intended outcome for students attending a program based on these units of instruction is to gain the competencies necessary to become entry level outboard marine technicians. It is these competencies which form the basis for arranging the Marine Engine Technology course into Units of Instruction. The Units and modules are listed on page 5 of this document. The first eleven units, with the exception of Unit 7 - Introduction to Sterndrive Systems, are listed in the basic order which they should be presented. Unit 7 is modeled after the Mercury Marine Two Week Basic Sterndrive training program and can be scheduled anytime after Unit 1 - Safety, Unit 2 - Tools, and Unit 6 -Gasoline Engines.

Each Unit of Instruction is made up of one or more Instructional Modules. Each module lists a competency, a set of instructional objectives, a suggested series of learning activities, and a model checklist which can be used as an aid for evaluating student performance. The modules also contain references and/or information sheets which can be used in lesson preparation. Some of the references should be purchased and kept in a classroom library so that students may have access to them. The information sheets can be photocopied and distributed. A module should be used as a reference when preparing individual lessons which will achieve the instructional objectives defined therein.

The evaluation of a student's ability to perform a newly taught service procedure needs to be more than a simple observation of results. The question, "Does it run or not?", is inadequate. In order to ensure that repairs to an outboard engine or any of its components will meet the test of time and durability each of the steps in the repair process must be done correctly. Therefore, the student's ability to perform each of the steps in a repair procedure must be observed to meet minimum standards. The modules which introduce a performance competency contain a performance checklist which should be used as a model when developing checklists for specific procedures.

The modules which have objectives that are primarily knowledge based contain master copies of multiple choice tests to help evaluate student knowledge. These tests make no references to specific products or O.E.M's and can be used as models to develop tests which evaluate specific product knowledge. A performance checklist is provided with each of these modules for the purpose of recording test scores.

Each module in the Instructor's Guide has a performance checklist. The complete set of checklists forms a record of a student's performance in the course. It is suggested that the instructor make a copy of the complete set of performance checklists for each student at the beginning of the course. The checklists should be kept in individual folders, one complete set per student. A copy of the Master Checklist, (provided in the Blank Forms section of this document, page 28), should be placed at the front of each student' folder. The Master Checklist has a check box for each module in the course. As a student masters the competencies in a module, (is "checked out" using the checklist in the module), the module checklist is placed in the student's folder, and the corresponding box on the master checklist is marked. When all of the boxes on the Master Checklist have been marked the student has completed the course.

MARINE ENGINE TECHNOLOGY

LIST OF UNITS AND MODULES

01.00 SAFETY
1. .01 Applying Safety and First Aid

02.00 TOOLS
2. .01 Using Hand Tools
3. .02 Using Power Tools
4. .03 Using Shop Tools
5. .04 Using Precision Measuring Tools

03.00 HARDWARE
6. .01 Identifying Fasteners
7. .02 Freeing Seized Hardware

04.00 SERVICE DOCUMENTATION
8. .01 Identifying Outboard Model/Year
9. .02 Using Service Manuals and Bulletins
10. .03 Finding Parts and Price Information
11. .04 Writing Service Orders

05.00 BOATS, BOAT TOWING, AND BOAT HANDLING
12. .01 Identifying Boat Hull Types
13. .02 Identifying Marine Propulsion Systems
14. .03 Boat Towing and Handling

06.00 GASOLINE ENGINES
15. .01 Selecting Fuels and Fuel Additives
16. .02 Piston Engine Fundamentals

07.00 INTRODUCTION TO STERNDRIVE SYSTEMS
17. .01 Identifying Year/Model Information
18. .02 Repairing Sterndrive Fuel Delivery Systems
19. .03 Repairing Sterndrive Charging and Starting Systems
20. .04 Repairing Sterndrive Ignition Systems
21. .05 Repairing Sterndrive Engines
22. .06 Repairing Sterndrive Trim And Tilt Systems
23. .07 Repairing Sterndrive Drive Systems

08.00 LUBRICANTS
24. .01 Identifying and Selecting Lubricants

09.00 ELECTRICITY
25. .01 Understanding Electricity

10.00 PAINTING
26. .01 Painting Outboard Motor Components

11.00 WELDING
27. .01 Using the Oxy-Acetylene and Arc Welders

12.00 OUTBOARD IGNITION SYSTEMS
28. .01 Performing the Basic Motor Inspection
29. .02 Identifying Ignition Systems
30. .03 Repairing and Maintaining Ignitions Systems
31. .04 Selecting Spark Plugs

13.00 OUTBOARD FUEL AND OIL SYSTEMS
32. .01 Repairing and Maintaining Fuel and Oil Delivery
33. .02 Repairing and Maintaining Carburetors and EFI

14.00 OUTBOARD POWERHEAD ELECTRICAL AND STARTING SYSTEMS
34. .01 Repairing and Maintaining Charging Systems
35. .02 Repairing and Maintaining Starting Systems
36. .03 Repairing Recoil Starters

15.00 OUTBOARD POWERHEAD
37. .01 Repairing The Outboard Powerhead
38. .02 Repairing and Maintaining Cooling Systems

16.00 THE OUTBOARD MIDSECTION
39. .01 Repair and Maintain Stern and Swivel Brackets
40. .02 Repairing and Maintaining Trim And Tilt Systems

17.00 GEARCASES
41. .01 Repairing Outboard Gearcases

18.00 OUTBOARD CONTROLS
42. .01 Repairing Steering and Remote Controls

19.00 RIGGING
43. .01 Choosing Wire
44. .02 Rigging Boat Electrical Accessories
45. .03 Rigging Outboard Engines
46. .04 Selecting Propellers
47. .05 Rigging Boat Accessories
48. .06 Rigging Trailers

20.00 JOB SEEKING SKILLS
49. .01 Preparing for the Job Search
50. .02 Resumes, Job Applications, and Letters of Application
51. .03 Interviewing for a Job
52. .04 Mapping Your Job Hunting Plans

MARINE ENGINE TECHNOLOGY

LIST OF COMPETENCIES

1. Avoid accidents by maintaining a safe work place and following safety procedures.
2. Describe first aid procedures.
3. Select and use hand tools for use in the repair of boats, trailers, and outboard motors.
4. Identify, use, and maintain electric and pneumatic power tools.
5. Identify, use and maintain shop tools.
6. Use precision measuring tools to make fine measurements.
7. Select and use common mechanical fasteners for repairing and maintaining outboard motors and boats.
8. Remove fasteners which have become seized and repair damaged threads as necessary.
9. Determine the model/year of Mercury Marine and OMC outboard motors.
10. Select service manuals and service bulletins to obtain information on service and maintenance procedures and specifications.
11. Look up Mercury and OMC outboard engine parts and accessories in:
    - Mercury printed parts catalog
    - Mercury Microcatalog Parts System
    - OMC printed parts catalog
    - OMC microfiche parts catalog
12. Verify Mercury part numbers.
13. Verify OMC part numbers.
14. Record customer and service information accurately on Service Order forms.
15. Recognize planing and displacement hulls.
16. Identify various types of planing boat hulls.
17. Name boat hull parts.
18. Recognize and name various types of marine propulsion systems.
19. Tow boats to and from test lake.
20. Launch and haul out boats at test lake.
21. Operate boats at test lake.
22. Select outboard motor fuel and additives.
23. Identify two stroke cycle and four stroke cycle engines.
24. Recognize drive systems and engines and identify their model year.
25. Use parts manuals, service manuals, and service bulletins to obtain service information.
26. Troubleshoot and repair sterndrive engine carburetors and fuel pumps.
27. Troubleshoot and repair sterndrive charging system.
28. Troubleshoot and repair sterndrive starting system.
29. Troubleshoot and repair sterndrive engine ignition systems.
30. Remove, disassemble, inspect, and reassemble in-line and V8 sterndrive engines.
31. Troubleshoot, disassemble, inspect, and repair sterndrive power trim and tilt system components.

32. Repair sterndrive transom plate assembly.
33. Repair sterndrive gear housing.
34. Repair sterndrive drive shaft housing.
35. Select and apply lubricants for the operation, repair, and maintenance of boats and engines.
36. Explain basic principles of electricity.
37. Identify electrical devices.
38. Read and interpret wiring diagrams.
39. Use a VOM/Multimeter to measure voltage, current, and resistance.
40. Repair damaged paint on outboard motor components.
41. Use the oxy/acetylene welding kit to cut and make simple butt and lap welds in light gauge steel.
42. Use an arc welder to make simple butt and lap welds in light gauge steel.
43. Perform a outboard motor basic inspection.
44. Recognize ignition systems and components.
45. Repair and adjust to specification outboard motor ignition systems.
46. Select and install spark plugs.
47. Identify fuel and oil system components.
48. Troubleshoot, and repair, the following outboard engine fuel and oil delivery system components:
    - fuel tanks
    - fuel lines
    - fuel pump
    - oil injection system
    - fuel enricher
49. Troubleshoot and repair carburetors.
50. Troubleshoot and repair electronic fuel injection system.
51. Troubleshoot and repair outboard engine charging system components.
52. Troubleshoot and repair starter, starter solenoid, starter key switch, and neutral safety devices.
53. Troubleshoot and repair outboard motor recoil starters.
54. Use basic motor inspection techniques to identify powerhead trouble.
55. Remove and reinstall powerhead.
56. Disassemble powerhead into its major components.
57. Disassemble, clean, inspect, reassemble crankshaft assembly.
58. Disassemble, clean, inspect, reassemble piston/rod assembly.
59. Disassemble, clean, inspect, repair cylinder block and crankcase.
60. Reassemble powerhead.
61. Troubleshoot and repair stern bracket.
62. Troubleshoot and repair swivel bracket.
63. Troubleshoot and repair drive shaft housing.
64. Troubleshoot and repair motor mounts.
65. Troubleshoot and repair power trim/tilt system.
66. Troubleshoot and repair outboard engine gearcases.
67. Troubleshoot and repair mechanical steering system components.
68. Troubleshoot and repair control boxes and control cables.
69. Select wire size according to repair or installation job requirements.
70. Troubleshoot, repair, and install boat electrical components and

accessories.

71. Install a single non-portable outboard engine and related components on a boat.
72. Select outboard engine propellers to obtain optimum boat performance.
73. Install accessories which mount on boat deck, hull, or transom.
74. Adjust boat and trailer combination for best towing performance.
75. Repair trailer boat bunks/rollers and adjust trailer to boat.
76. Repair and maintain trailer wheels and axles.
77. Repair and install trailer lights.
78. Install trailer accessories.
79. Identify those tools you ned to find a job and utilize the most effective methods for identifying prospective employers.
80. Apply written communication skills and prepare a resume, professional profile, job application, and appropriate cover letters.
81. Use effective communication skills in a job interview.
82. Develop a specific map for job hunting.

11

MARINE ENGINE TECHNOLOGY

SUGGESTED ASSIGNMENT OF INSTRUCTIONAL HOURS

UNIT/MODULE	HOURS (1320)	CONVERSION FACTOR **
01.00 SAFETY		
.01 Applying Safety and First Aid	25	.0189
02.00 TOOLS		
.01 Using Hand Tools	10	.0076
.02 Using Power Tools	15	.0114
.03 Using Shop Tools	10	.0076
.04 Using Precision Measuring Tools	30	.0227
03.00 HARDWARE		
.01 Identifying Fasteners	20	.0152
.02 Freeing Seized Hardware	30	.0227
04.00 SERVICE DOCUMENTATION		
.01 Identifying Outboard Model/Year	15	.0114
.02 Using Service Manuals and Bulletins	15	.0114
.03 Finding Parts and Price Information	15	.0114
.04 Writing Service Orders	15	.0114
05.00 BOATS, BOAT TOWING, AND BOAT HANDLING		
.01 Identifying Boat Hull Types	20	.0152
.02 Identifying Marine Propulsion Systems	30	.0227
.03 Boat Towing and Handling	30	.0227
06.00 GASOLINE ENGINES		
.01 Selecting Fuels and Fuel Additives	40	.0303
.02 Piston Engine Fundamentals	40	.0303
07.00 INTRODUCTION TO STERNDRIVE SYSTEMS		
.01 Identifying Year/Model Information	10	.0076
.02 Repairing Fuel Delivery Systems	15	.0114
.03 Repairing Charging and Starting Systems	15	.0114
.04 Repairing Ignition Systems	15	.0114
.05 Repairing Sterndrive Engines	15	.0114
.06 Repairing Trim And Tilt Systems	15	.0114
.07 Repairing Drive Systems	15	.0114
08.00 LUBRICANTS		
.01 Identifying and Selecting Lubricants	20	.0152
09.00 ELECTRICITY		
.01 Understanding Electricity	60	.0455
10.00 PAINTING		

.01	Painting Outboard Motor Components	10	.0076
11.00	WELDING		
.01	Using the Oxy-Acetylene and Arc Welders	80	.0606
12.00	OUTBOARD IGNITION SYSTEMS		
.01	Performing the Basic Motor Inspection	10	.0076
.02	Identifying Ignition Systems	80	.0606
.03	Repairing and Maintaining Ignitions Systems	90	.0682
.04	Selecting Spark Plugs	5	.0038
13.00	OUTBOARD FUEL AND OIL SYSTEMS		
.01	Repairing and Maintaining Fuel and Oil Delivery	30	.0227
.02	Repairing and Maintaining Carburetors and EFI	60	.0455
14.00	O/B POWERHEAD ELECTRICAL AND STARTING SYSTEMS		
.01	Repairing and Maintaining Charging Systems	20	.0152
.02	Repairing and Maintaining Starting Systems	30	.0227
.03	Repairing Recoil Starters	10	.0076
15.00	OUTBOARD POWERHEAD		
.01	Repairing The Outboard Powerhead	60	.0455
.02	Repairing and Maintaining Cooling Systems	40	.0303
16.00	THE OUTBOARD MIDSECTION		
.01	Repair and Maintain Stern and Swivel Brackets	10	.0076
.02	Repairing and Maintaining Trim And Tilt Systems	30	.0227
17.00	GEARCASES		
.01	Repairing Outboard Gearcases	40	.0303
18.00	OUTBOARD CONTROLS		
.01	Repairing Steering and Remote Controls	10	.0076
19.00	RIGGING		
.01	Choosing Wire	5	.0038
.02	Rigging Boat Electrical Accessories	40	.0303
.03	Rigging Outboard Engines	40	.0303
.04	Selecting Propellers	15	.0114
.05	Rigging Boat Accessories	10	.0076
.06	Rigging Trailers	15	.0014
20.00	EMPLOYABILITY SKILLS		
.01	Preparing for the Job Search	10	.0076
.02	Resumes, job applications, and Letters of Application	10	.0076
.03	Interviewing for a Job	10	.0076
.04	Mapping Your Job Hunting Plans	10	.0076
		=====	
		1320	

** The CONVERSION FACTOR is the per cent total of the course for each module. This number can be used to adjust the number of hours allocated to each module for varying course total hours.

EXAMPLE: For a course total of 1100 hours find the new number of hours for module 20.02.

Module 20.02 conversion factor = .0227

1100 X .0227 = 24.97

Rounding we get 25.0 hours

REFERENCES

"The Tools & Rules For Precision Measuring",
Bulletin No. 1211, Issue 3, 11-1-83,
The L.S. Starrett Co.
Athol, MA 01331

"Everything You Need To Know About Propellers.", Third Edition
Mercury Marine
P/N 90-86144.

"Boating Skills and Seamanship", Tenth Edition, First Printing
United States Coast Guard Auxiliary,
Coast Guard Auxiliary National Board, Inc.
Washington, DC.
Library of Congress number 74-164-688.
ISBN 0-930028-03-1.

"The Performance Boat Bible", by Earl Bentz and Don Wirth,
(c) 1983 by Earl Bentz and Don Wirth.
Published by B&W Publications
P.O.Box 40405
Nashville, TN 37204.

"The Fiberglass Boat Handbook", by Jack Wiley
(c) 1987 by TAB Books Inc.
P.O. Box 40
Blue Ridge Summit, PA 17214
ISBN 0-8306-0399-9

"Modern Boatbuilding Materials and Methods"
Steve Sleight
(c) 1985 Steve Sleight
Published by International Marine Publishing Co.
21 Elm St.
Camden, Maine 04842.
(207) 236-4342.
Library of Congress no. 85-04561.
ISBN 087742-210-9.

"Living With Unleaded", an article by Marlan Davis
Hot Rod Magazine Engines
Petersen's Yearbook Series
Volume 2, Number 2, 1988
Petersen Publishing Company
8490 SUnset Blvd.
Los Angeles, CA 90069
(213) 854-2222

"Booster Shot" an article by Marlan Davis

Hot Rod Magazine Engines
Petersen's Yearbook Series
Volume 2, Number 2, 1988
Petersen Publishing Company
8490 SUnset Blvd.
Los Angeles, CA 90069
(213) 854-2222

"Know what you're putting in your tank, Facts on alcohol blend fuels", a pamphlet by the
United States Coast Guard,
BOAT/U.S. Foundation
880 S. Pickett St.
Alexandria VA 22304

"Alcohol: The final word (hopefully) on the no-lead, alcohol-additive fuel controversy and what it means to trailerboaters", an article from
Trailer Boats Magazine, Vol 15, No. 1, Jan 1986
16427 South Avalon
P.O. Box 2307
Gardena, CA 90248
(213) 323-9040

"Lubricants and Hydraulic Fluids: what they do and why"
Form 8417. Revised 2/89.
Kendall Refining Company Division of Witco Corporation
Bradford, PA 16701
(814) 368-6111

"Your Boat's Electrical System", 2nd revised edition
Conrad Miller, Elbert S. Maloney
The Hearst Corporation
1988, ISBN 0-688-08132-0

"Ignition and Charging Systems".
1986 Marine Seminar Workbook
Yamaha Motor Corporation, U.S.A.

"OMC Magneto/CD Ignition System Theory".
Part 406412.
Outboard Marine Corporation of Canada Ltd.
Peterborough, Canada

1986 NMMA Certification Handbook
National Marine Manufacturer's Association
401 North Michigan Avenue
Chicago, IL 60611

"Spark Plug Selection", an article by Matthew Prendergast
from "Engines", Petersen's Yearbook Series, Volume 2, Number 2, 1988
Petersen Publishing Company
8490 Sunset Blvd.

Los Angeles, CA 90069
(213) 854-2222

Job Seeking Skills
(An instructional manual)
Jill Stiemsma
Moraine Park Technical College
235 North National Avenue
Fond du Lac, WI 54935

MARINE ENGINE TECHNOLOGY

LIST OF A/V MATERIALS

1. Manufacturer's product-line videotapes.
These are the tapes produced by manufacturers to display and announce their engine product-lines. Contact O.E.M's directly for these tapes.

2. Videotape
"Power Boating Volume II. Single Screw Boat Handling, Trailerable".
Neptune Productions
9770 San Fernando Road
Sun Valley, CA 91352

3. Videotape
"The New Boater's Video".
AM Tech Video, Inc.
6601 Smith Rd.
Cleveland, OH 44130
(216) 676-0441

4. Filmstrip/Audio Cassette
"Basic Theory of Operation for the Two-stroke Cycle Engine".
P/N 59-9 OB
OMC Training Department
3145 Central Avenue, Desk C-613
Waukegan, IL 60085
(312) 689-5531

5. Videotape
"Introduction to CDII Ignitions"
P/N VT799 OB
OMC Service Dept., Desk C-13
3145 Central Ave.
Waukegan, IL 60085
(312)629-7192

6. Videotape
"Principles of Spark-Throttle Adjustment"
P/N VT707OB
OMC Training Department
3145 Central Avenue, Desk C-613
Waukegan, IL 60085
(312) 689-5531

7. Videotape
"Introduction to the Counter-rotating V6 Outboard Gearcases"
P/N 79173
OMC Training Department
3145 Central Avenue, Desk C-613

Waukegan, IL 60085
(312) 689-5531

8. Videotape
"Using The P/N 393185 Shim Gauge"
P/N VT8330BSD
OMC Training Department
3145 Central Avenue, Desk C-613
Waukegan, IL 60085
(312) 689-5531

9. Videotape
"Safety and Rigging"
P/N VT7980B
OMC Training Department, Desk C-613
3145 Central Avenue
Waukegan, IL 60085
(312) 689-5531

10. Videotape
"Propping Out"
P/N VT7820B
OMC Training Department
3145 Central Avenue, Desk-613
Waukegan, IL 60085
(312) 689-5531

11. Videotape
"The Makings of an SST Propeller"
P/N 76402
OMC Training Department
3145 Central Avenue, Desk-613
Waukegan, IL 60085
(312) 689-5531

LIST OF INFORMATION SHEETS

The following Information sheets were developed specifically for use with this Marine Mechanics Instructor Guide. A master copy of each Information Sheet can be found in its associated module.

"Basic Hand Tools", module 02.01

"Mechanical Fasteners", module 03.01

"Setting Up the Oxy-Acetylene Torch For Heating", module 03.02

"Removing Seized Fasteners", module 03.02

"Restoring Destroyed Threads In Aluminum Castings", module 03.02

"Determining the Model Year of Outboard Motors", module 04.01

"Selecting Mercury Marine and OMC Service Manuals and Service Bulletins", module 04.02

"Looking Up Parts and Price Information", module 04.03

"Filling In Service Orders Properly", module 04.04

"Detonation and Preignition Causes", module 06.01

"Two Cycle Engine Principles", module 06.02

"Mercury Marine Outboard Cylinder Charging", module 06.02

"Theory of Operation of Two Cycle Engines", module 06.02

"Four Stroke Cycle Operation", module 06.02

"The Basic Motor Inspection", module 12.01

"Ignition System Model History", module 12.02

"Magneto Type CD Ignitions", module 12.02

"Ignition System Safety Procedures", module 12.02

"Troubleshooting Magneto Ignitions", module 12.03

"Troubleshooting Magneto CD Ignitions", module 12.03

"Spark Plug Removal and Installation", module 12.04

LIST OF SUGGESTED EQUIPMENT

SHOP TOOLS

A - Quantity depends on item availability
CS - Quantity depends on class size

1.	1	Air Compressor, 15HP, plumbed to workstations in shop
2.	CS	Air Hoses, quick release
3.	1	Ammeter, 0 - 50A
4.	1	Ammeter, 0 - 200A
5.	1	Anvil
6.	1	Arbor Press, 8" min.
7.	1	Arc Welder Set, AC/DC
8.	1	Battery Service Bench
9.	1	Battery, starting, with 12" jumper cables and cart
10.	1	Battery Charger
11.	1	Battery Electrolyte Hydrometer
12.	1	Battery Water Dispenser
13.	1	Battery Load Tester
14.	1	Battery Cable Terminal Crimper
15.	1	Bead Blast Cabinet
16.	1	Boat Wash-down equipment
17.	1	Bore Gauge, U.S., 1-7/8" - 4"
18.	2	Bottle Jack
19.	1	C Clamp Set
20.	2	Cart, rolling, for portable outboard fuel tanks
21.	1	Chain Hoist, 2 TON
22.	1	Chalkboard, portable for use in shop
23.	1	Cylinder Hone Kit, 1-7/8" to 4"
24.	1	Dial Caliper, 0" - 6", outside/inside
25.	1	Dial Caliper, metric
26.	1	Dial Indicator Kit, universal, incl. magnetic base
27.	2	Drain Pans, oil
28.	1	Drill Bit Set, fractional, lettered, numbered
29.	1	Drill Bit Sharpener
30.	1	Drill motor, 1/2" electric
31.	1	Drill Press, min. 24" work height
32.	1	Drop light
33.	1	Dynamometer, marine
34.	A	Engine Cut-aways
35.	1	Engine Flush Attachments, assorted
36.	1	Engine Hoist, outboard
37.	CS	Engine Stands, outboard, rolling and fixed
38.	1	Engine Test Tank, back-in, with Davit and exhaust ventilator
39.	1	Engine Test Tank, lift-in, with Davit and exhaust ventilator
40.	1	Engine Test Wheels, for assorted HP
41.	CS	Engine Workstation with powerhead and gearcase adapters

42.	CS	Engines, complete outboard, 1 cyl, 2 cyl, 3 cyl, 4 I/L, V4, 6 I/L, V6
43.	1	Engraver, electric
44.	2	Extension Cord, 50'
45.	1	Fan, 18", on floorstand for air circulating
46.	1	First Aid Kit
47.	1	Floorjack
48.	1	Fuel Pressure Gauge
49.	CS	Fuel Tanks, portable, with fuel lines for various O.E.M's
50.	A	Gearcase Cut-aways
51.	1	Gearcase Pressure Tester
52.	1	Gearcase Vacuum Tester
53.	1	Grease Gun, cartridge type
54.	1	Grinder, 4" high speed electric
55.	1	Grinder, 4" or 6", Bench type with Pedestal
56.	1	Grinder Wheel Dresser
57.	1	Hand Truck, general purpose
58.	1	Heli-Coil Installation Kits, assorted common sizes incl. spark plug
59.	1	Hole Saw Kit
60.	1	Ignition Analyzer, Stevens
61.	1	Ignition Analyzer, Merc-o-Tronic
62.	1	Impact wrench, 1/2" pneumatic, with impact socket set
63.	2	Jack Stands
64.	1	Microfiche Reader
65.	1	Micrometer Set, outside, 0" - 6" with case and standards
66.	1	Micrometer Set, metric
67.	1	Micrometer Set, depth, 0" - 4", with case and standards
68.	1	Micrometer Set, metric depth
69.	1	Oven, for parts heating
70.	2	Peak Reading Voltmeter, CD77
71.	1	Power Hone, tool sharpening
72.	1	Parts Books or Microfiche, complete set per O.E.M
73.	1	Parts Washer, 20 gallon
74.	1	Pneumatic Hammer Kit
75.	1	Pop-rivet Kit
76.	1	Propeller Puller
77.	1	Puller Kit, jaw type, general purpose
78.	1	Pump Lid for 30lb. gear lube pail
79.	1	Refrigerator, general purpose
80.	1	Retaining Ring Plier Set
90.	1	Saw, Sabre, with blade assortment
91.	1	Saw, Reciprocating, with blade assortment
92.	1	Saw, Circular, 7-1/2", with general purpose carbide tipped blade
93.	1	Service Manuals, complete set per O.E.M.
94.	1	Shaft Balancer
95.	1	Sheet Metal Snips
96.	1	Slide Hammer Set, 5lb., with general purpose accessories
97.	1	Soldering Iron Kit
98.	1	Special Tool Sets, one per O.E.M
99.	1	Step Ladder, 2'

100.	1	Step Ladder, 8'
101.	1	Surface plate, 24"x 24"
102.	1	Tachometer, inductive
103.	1	Tap and Die Set, standard and metric
104.	1	Tape Measure, 25'
105.	1	Test Light
106.	1	Timing Light, inductive
107.	1	Tire Pressure Gauge
108.	1	Torque Wrench, 1/4" drive, in.lb./Nm
109.	1	Torque Wrench, 3/8" drive, in.lb./Nm
110.	1	Torque Wrench, 3/8" drive, ft.lb./Nm
102.	1	Torque Wrench, 1/2" drive, 200 ft.lb./Nm
103.	1	Trailer Tongue Dolly
104.	1	Vacuum Cleaner, shop duty
105.	CS	Vise, 6" Mechanic's
106.	1	VOM/Multimeter with test leads
107.	1	Waste Oil Disposal Tank
108.	1	Water Hose
109.	1	Welding Helmet equipped with appropriate filter
110.	1	Welding Gloves
111.	1	Welding Table with brick top
112.	1	Welding Kit, Oxy-acetylene, with Cart
113.	1	Wheel Bearing Driver Set
114.	CS	Workbench, steel, top 42"x84"
115.	CS	Workbench Stools

STUDENT TOOL KIT

1 KIT PER TWO STUDENTS

ALL PART NUMBERS ARE SNAP-ON UNLESS OTHERWISE NOTED. ALL QUANTITIES ARE 1EA.

1.	Z18SFP	6pt. Socket set (18 pcs.)
2.	F101	12pt. Socket, 5/16", 3/8" drive
3.	CM3070	6in. Pocket scale
4.	TMX-140	14in. Extension
5.	PT 28-C	Extension magnet
6.	SA 256-A	Mechanical fingers
7.	4A 132	Safety glasses
8.	MT 27B	Compression gauge
9.	JT 13	Air gun
10.	JT 10AS	Air gun
11.	S9706	Socket, spark plug, 5/8"
12.	S9704	Socket, spark plug, 13/16"
13.	OMC	Carburetor orifice tool
14.	Z06 AFS	Universals, 6pt flank drive (6pcs.)
15.	TMU-141	Flexocket, 7/16", 1/4" drive (14pcs.)
16.	114 TMP SET	Socket set, 1/4" drive
17.	124STTM	Socket set, metric 4mm - 14mm, 1/4" drive, standard and deep
18.	111TMUSMY	Flexocket set, metric 5.5mm - 15mm, 1/4" drive
19.	224SFFSMM	Socket set, metric 8mm - 19mm, 3/8" drive, standard and deep
20.	320TSWM	Socket set, metric 10mm - 20mm, 1/2" drive, standard and deep
21.	211BFSY SET	Socket set, deep well, 3/8" drive,(11pcs.)
22.	AW5-K	Hex wrench set, standard
23.	AW9-K	Hex wrench set, standard
24.	AWM11OCK	Hex wrench set, metric
25.	FB 316B	Ignition gauge
26.	90AP	Pliers, Channel locks
27.	HCP 46BP	Pliers, hose clamp
28.	87	Diagonal cutters
29.	196	Pliers, needle nose, 7 1/8"
30.	DA-210	Adjustable wrench, 10"
31.	PWC 6	Wire stripper
32.	PWC 13	Pliers, crimping
33.	YA-824A	Pliers, High tension
34.	VP-7WR	Pliers, vise grip
35.	OEXM713	Combination wrench set, metric long, 10mm - 20mm
36.	OEXSM708	Combination wrench set, metric standard, 6mm - 13mm
37.	OEXS709	Combination wrench set, short 12pt. flank drive, 9pcs.
38.	OEX709	Combination wrench set, long 12pt. flank drive, 9pcs.

39.	316 MSP	Socket set, 6pt. 1/2" drive (16pcs.)
40.	TWA421	Socket, 1-5/16"
41.	SDX 80	Screwdriver set, combination
42.	SSDP 63	Screwdriver, Phillips
43.	CSA 8	Gasket scraper, 7/8" wide
44.	CSA 12	Gasket scraper, 1" wide
45.	PPC 710 A	Punch and Chisel set (11pcs.)
46.	14V7	Flexible curved tooth file, Vixen
47.	PPC 5	Punch and Chisel holder
48.	208 PIT	Impact driver set
49.	FP 720	Air impact wrench
50.	BPN 16 B	Hammer, 16oz. ballpeen
51.	BE 124	Hammer, 24oz. plastic tip
52.	ECF1A	Flashlight
53.	HS-8A	Hacksaw
54.	2011-C-1T-K	Ignition tune-up set (14pcs.)
55.		24" Jumper wires, 1 black & 1 red, 10ga., with alligator clips
56.	KRA 59 J	Tool chest, 3 drawer
57.	KRA 380 E	Storage cabinet, rolling
58.	MT302	Remote Starter Switch
59.	SPB18	Pry bar
60.	HB500	File set

MARINE ENGINE TECHNOLOGY

OBJECTIVES FOR STUDENT ORIENTATION

The objectives of the orientation session in Marine Mechanics consist of the following :

To introduce the instructor to the students and introduce the students to the instructor and each other. The instructor should give the class a brief summary of his background in Marine Mechanics and as a Marine Mechanics Instructor. The students should tell of their backgrounds and say something about their reasons for choosing Marine Mechanics as a career.

To familiarize the students with their school and its Vocational and Academic programs and its campus. The students should receive a campus map so that they can find the cafeteria, library, Administration building. The students should be advised of the various programs on campus which are available to help them personally, academically, and financially. The students should be given the names of the persons in charge of the programs and the names of their offices.

To make known the Marine Mechanics policies and/or rules regarding the attendance of class. Tell the students what the sign-in/sign-out procedures are. Tell what effect absences will have on their success in the program. Tell what the notification procedure is on the occasion of their absence. Tell what the formal warning procedure is and what it means.

To advise the students about the availability of cooperative education opportunities. Tell the students what cooperative education in Marine Mechanics is about. Let them know what opportunities exist and where they are.

To explain what the Marine Mechanics curriculum is and what they can expect to learn during the program. Hand out a course outline. Explain the objectives. Tell something about what past program completers have accomplished.

To explain how student performance will be evaluated. Tell what methods will be used to evaluate student performance in the shop and in the classroom. Explain the system for recording student performance. Tell what level of performance is required to successfully complete the program.

To make the class schedule understood. Hand out a copy of the schedule to each student. Make sure that all class days and times are understood. Point out the beginning and ending dates for each term. Point out registration dates. Explain the re-registration process if required. Go over all the holidays.

To explain the opportunity for student involvement in VICA. Give a VICA presentation which describes the club or get past/current VICA officers to do so. Tell of the success of past Marine Mechanics students in the VICA Marine Mechanics competitions. Explain how to get involved.

To familiarize the students with the Marine Mechanics facility. Give a shop tour stopping to name the large pieces of equipment, storage areas, areas which require extra safety precautions, etc.

To make tool box assignments. Make the assignments. Take inventories. Explain policies and procedures.

BLANK FORMS

This section contains a blank copy of the Performance Checklist and The Master Checklist. These forms were designed for typewriters or printers which print at 6 LPI, (Lines Per Inch).

NAME____________________________ STUDENT NO.____________________________

PERFORMANCE CHECKLIST

MODULE :

COMPETENCY:

1. ☐
2. ☐
3. ☐
4. ☐
5. ☐
6. ☐
7. ☐
8. ☐
9. ☐
10. ☐
11. ☐
12. ☐
13. ☐
14. ☐
15. ☐

COMPETENCY ACHIEVED? ☐ YES ☐ NO

EXPLANATION:

MASTER CHECKLIST

NAME________________________________ STUDENT NO.______________

	MOD #	DESCRIPTION	COMPETENCY ACHIEVED?
1.	01.01	Applying Safety and First Aid	☐
2.	02.01	Using Hand Tools	☐
3.	02.02	Using Power Tools	☐
4.	02.03	Using Shop Tools	☐
5.	02.04	Using Precision Measuring Tools	☐
6.	03.01	Identifying Fasteners	☐
7.	03.02	Freeing Seized Hardware	☐
8.	04.01	Identifying Outboard Model/Year	☐
9.	04.02	Using Service Manuals and Bulletins	☐
10.	04.03	Finding Parts and Price Information	☐
11.	04.05	Writing Service Orders	☐
12.	05.01	Identifying Boat Hull Types	☐
13.	05.02	Identifying Marine Propulsion Systems	☐
14.	05.03	Boat Towing and Handling	☐
15.	06.01	Selecting Fuels and Fuel Additives	☐
16.	06.02	Piston Engine Fundamentals	☐
17.	07.01	Identifying I/O Year/Model Information	☐
18.	07.02	I/O Fuel Delivery Systems	☐
19.	07.03	I/O Charging and Starting Systems	☐
20.	07.04	I/O Ignition Systems	☐
21.	07.05	I/O Engines	☐
22.	07.06	Repairing I/O Trim and Tilt Systems	☐
23.	07.07	Repairing I/O Drive Systems	☐

COMPETENCY	MOD #	DESCRIPTION	ACHIEVED?
24.	08.01	Identifying and Selecting Lubricants	☐
25.	09.01	Understanding Electricity	☐
26.	10.01	Painting Outboard Motor Components	☐
27.	11.01	Using the Oxy-Acetylene and Arc Welders	☐
28.	12.01	Performing the Basic Motor Inspection	☐
29.	12.02	Identifying Ignition Systems	☐
30.	12.03	Repairing and Maintaining Ignitions Systems	☐
31.	12.04	Selecting Spark Plugs	☐
32.	13.01	Repairing and Maintaining Fuel and Oil Delivery	☐
33.	13.02	Repairing and Maintaining Carburetors and EFI	☐
34.	14.01	Repairing and Maintaining Charging Systems	☐
35.	14.02	Repairing and Maintaining Starting Systems	☐
36.	14.03	Repairing Recoil Starters	☐
37.	15.01	Repairing The Outboard Powerhead	☐
38.	15.02	Repairing and Maintaining Cooling System	☐
39.	16.01	Repair and Maintain Stern and Swivel Brackets	☐
40.	16.02	Repairing and Maintaining Trim And Tilt Systems	☐
41.	17.01	Outboard Gearcases	☐
42.	18.01	Repairing Steering and Remote Controls	☐
43.	19.01	Choosing Wire	☐
44.	19.02	Rigging Boat Electrical Accessories	☐
45.	19.03	Rigging Outboard Engines	☐
46.	19.04	Selecting Propellers	☐
47.	19.05	Rigging Boat Accessories	☐

	MOD #	DESCRIPTION	COMPETENCY ACHIEVED?
48.	19.06	Rigging Trailers	☐
49.	20.01	Preparing for the Job Search	☐
50.	20.02	Resumes, Job Applications, Letters of Applicat.	☐
51.	20.03	Interviewing for a Job	☐
52.	20.04	Mapping Your Job Hunting Plans	☐

UNIT 1 - SAFETY

MODULE 01.01

APPLYING SAFETY AND FIRST AID **INSTRUCTOR GUIDE**

COMPETENCY:

1. Avoid accidents by maintaining a safe work place and following safety procedures.
2. Describe first aid procedures.

INSTRUCTIONAL OBJECTIVES:

The student will be able to:

1. Explain the purpose for having safety regulations.
2. Dress properly for the shop environment.
3. Recognize eye hazards and put on appropriate eye protectors.
4. Prevent back injuries by using correct lifting techniques.
5. Locate and use fire extinguishers.
6. Locate and use emergency electrical cutoff switch.
7. Contact emergency personnel in case of an accident with injuries.
8. Describe the procedure to use if someone is injured in the shop.
9. Locate the first aid kit.
10. State first aid procedures for cuts and burns.
11. State first aid procedures for accidents in which someone has gotten chemicals into their eyes and/or on their skin.

LEARNING ACTIVITIES:

1. Participate in class lectures and discussions.
   (Objectives 1 - 11)

2. Go into the shop and find the following pieces of safety related equipment. Memorize the location of each.
   - Electrical emergency cutoff switch
   - All fire extinguishers
   - First aid kit
   - Emergency wash stations

   (Objectives 5 - 7)

EVALUATION/CHECK-OUT:

The instructor will evaluate your ability to follow safety procedures as you perform tasks in the shop. Hopefully, your knowledge of first aid procedures will not be required. To test you preparedness the instructor will quiz you verbally from time to time. Your performance will be recorded on the performance checklist.

RESOURCES:

LEARNING MATERIALS:

MODULE 01.01

1. Information Sheet
   "Who To Call and Their Telephone Numbers"
   (Prepare this sheet with names/numbers as required by your area of the campus/community.)

EQUIPMENT:
(none used)

AUDIO VISUAL MATERIALS:
(none used)

NAME______________________ STUDENT NO.______________________

01.01 **PERFORMANCE CHECKLIST**

MODULE : APPLYING SAFETY AND FIRST AID

COMPETENCY: Avoid accidents by maintaining a safe work place and following safety procedures.

1. ☐ Explained purpose of safety procedures and regulations
2. ☐ Dresses safely
3. ☐ Recognizes eye hazards and uses eye protection
4. ☐ Uses safe lifting techniques
5. ☐ Explained operation of fire extinguisher
6. ☐ Explained operation of emergency electrical cutoff
7. ☐ Explained safety benefits of maintaining a clean shop
8. ☐
9. ☐
10. ☐
11. ☐
12. ☐
13. ☐
14. ☐
15. ☐

COMPETENCY ACHIEVED? ☐ YES ☐ NO

EXPLANATION:

NAME__________________________ **STUDENT NO.**__________________________

01.01

PERFORMANCE CHECKLIST

MODULE : APPLYING SAFETY AND FIRST AID

COMPETENCY: Describe first aid procedures

1. ☐ Explained procedure for getting emergency help
2. ☐ Knows location of all first aid equipment
3. ☐ Described first aid for cuts/bleeding
4. ☐ Described first aid for burns
5. ☐ Described first aid for chemical/acid spills
6. ☐ Explained accident reporting procedures
7. ☐
8. ☐
9. ☐
10. ☐
11. ☐
12. ☐
13. ☐
14. ☐
15. ☐

COMPETENCY ACHIEVED? ☐ **YES** ☐ **NO**

EXPLANATION:

UNIT 2 - TOOLS

MODULE 02.01

USING HAND TOOLS **INSTRUCTOR GUIDE**

COMPETENCY:
Select and use hand tools for use in the repair of boats, trailers, and outboard motors.

INSTRUCTIONAL OBJECTIVES:

The student will be able to:
1. Identify and use :
   - screwdrivers,
   - end wrenches,
   - socket wrenches,
   - hammers,
   - chisels and punches,
   - pliers and cutters,
   - hacksaw and files,
   - parts clean-up tools,
   - pickup tools.

LEARNING ACTIVITIES:
1. Participate in class lectures and discussions.
2. Read the Information Sheet, "Basic Hand Tools".
3. Go to your tool box or the tool room. Locate and examine the different types of each of the basic hand tools.
4. Inventory your tool box.

EVALUATION/CHECK-OUT:
The instructor will observe and evaluate your selection and use of hand tools throughout the course. Always be sure to take the time to select the correct tool for a job. Practice correct usage. Your performance will be recorded on the performance checklist.

RESOURCES:

LEARNING MATERIALS:
1. Information Sheet
   "Basic Hand Tools"
   (Master copy included in this guide.)
   This Information Sheet adapted from Introduction To Automotive Mechanics--Student Guide, State of Florida, Department of Education, Tallahassee, Florida, 1979.

EQUIPMENT:
Examples of each of tools in the basic set of hand tools. Preferably sets of hand tools assigned to students. See the Tools and Equipment section of this guide for recommended

tool set contents.

AUDIO VISUAL MATERIALS:

(none used)

NAME_____________________________ STUDENT NO._____________________________

02.01 **PERFORMANCE CHECKLIST**

MODULE : Hand Tools

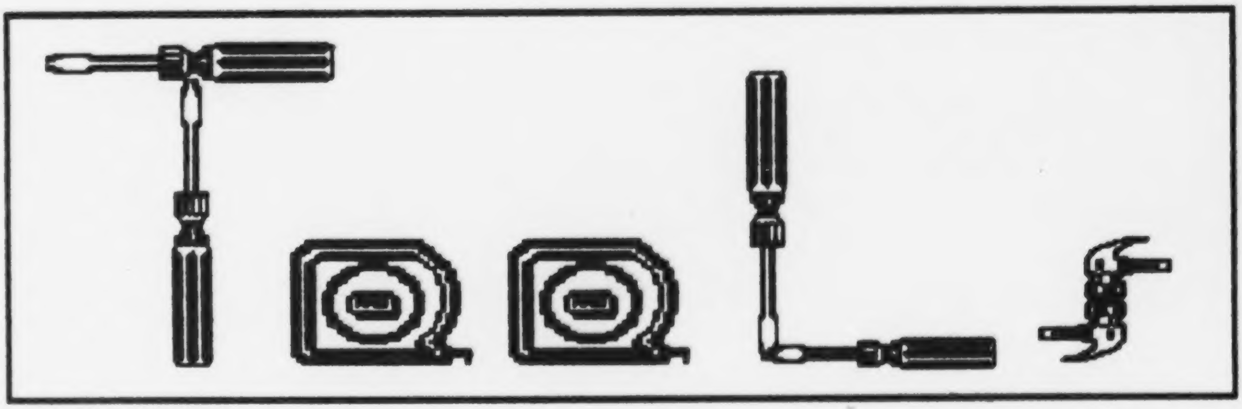
COMPETENCY: Select and Use Hand Tools

1. ☐ Screwdrivers
2. ☐ End Wrenches
3. ☐ Socket Wrenches and Accessories
4. ☐ Hammers
5. ☐ Hacksaw and Files
6. ☐ Chisels and Punches
7. ☐ Parts Cleaning Tools
8. ☐ Pickup Tools
9. ☐ Pliers and Cutters
10. ☐ Maintained Tools
11. ☐
12. ☐
13. ☐
14. ☐
15. ☐

COMPETENCY ACHIEVED? ☐ YES ☐ NO

EXPLANATION:

HAND TOOLS INFORMATION SHEET



Almost every service or maintenance procedure for an outboard motor requires the use of some kind of hand tool. In order to select the proper hand tools to perform a service or maintenance procedure, you must be able to identify hand tools and know how to use them. This information sheet will help you learn how to identify basic hand tools and know how to use them.

SCREWDRIVERS

Screwdrivers are made to be used with different kinds of screws. Each screwdriver is named after the type of screw it is used for. Always use the proper screwdriver to remove and install screws quickly and easily. Do not use a screwdriver to scrape, chisel, punch, or pry.

Screwdrivers have two main parts: the blade and the handle. The blade consists of a square or round shank and a tip. A square shank allows you to use a wrench on the screwdriver to help tighten screws (see Figure 1-1).

There are five types of screwdrivers found in a basic hand tool set: standard, Phillips, clutch-head, offset, and screw starter.

Figure 1-1 Standard screwdriver

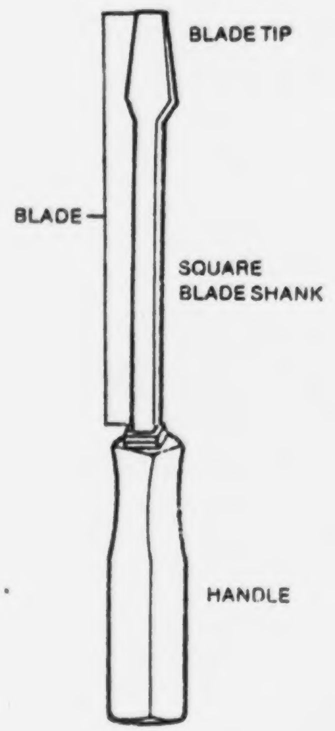
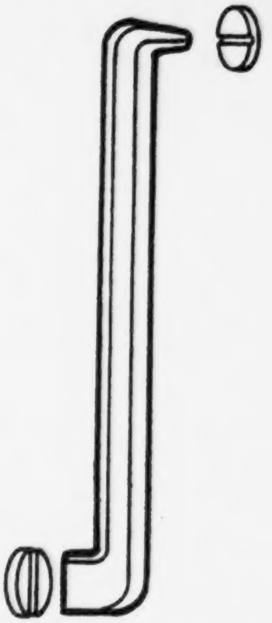


Figure 1-8 Offset screwdriver and screws



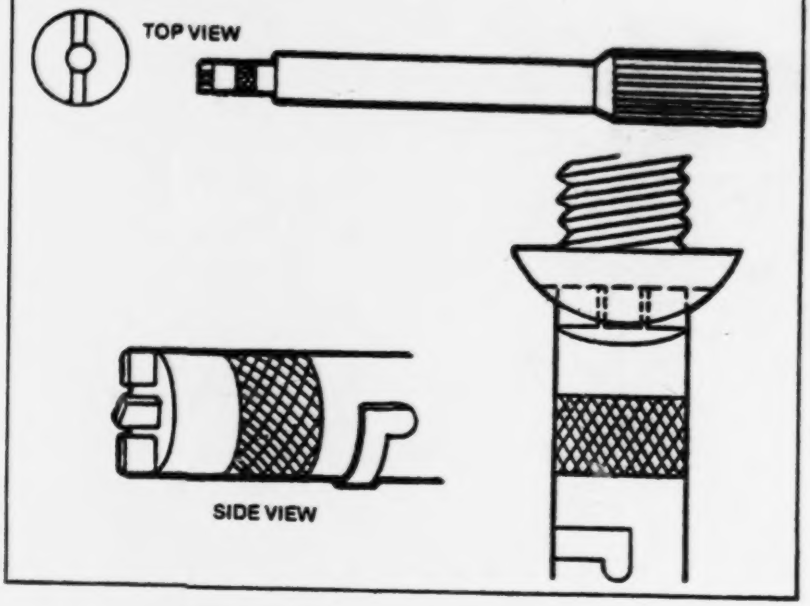
Offset Screwdriver

The offset screwdriver is designed to be used when the screw is hard to reach. The blades and tips are set at right angles to the handle and at right angles to each other (see Figure 1-8).

Screw Starters

Screw starters have a twist center to hold the screw. These screwdrivers are made with Phillips or standard tips. Screw starters are used to help you begin turning screws in hard-to-reach places (see Figure 1-9).

Figure 1-9 Screw starters



Standard Screwdriver

Standard screwdrivers are used on bolts and screws with slotted heads (see Figure 1-2). These screwdrivers come in many different sizes, shapes, and lengths. The size of the screwdriver is determined by the length and diameter of its blade. The blade tip is usually the same width as the shank. Figures 1-3 and 1-4 show you how standard screwdrivers vary in size and shape.

Make sure the screwdriver blade fits properly into the head of the screw (see Figure 1-5). The blade tip or the screw can be damaged if the blade does not fit properly.

Figure 1-2 Standard tip and screw

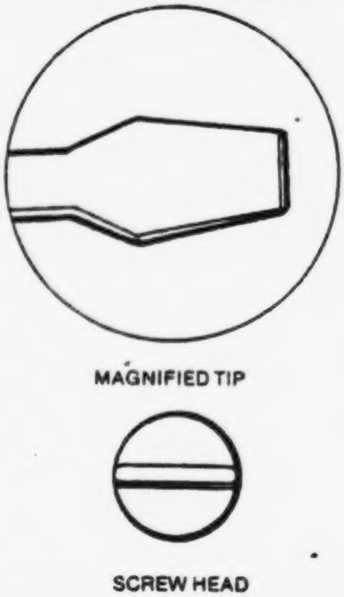


Figure 1-3 Square shank and bolster

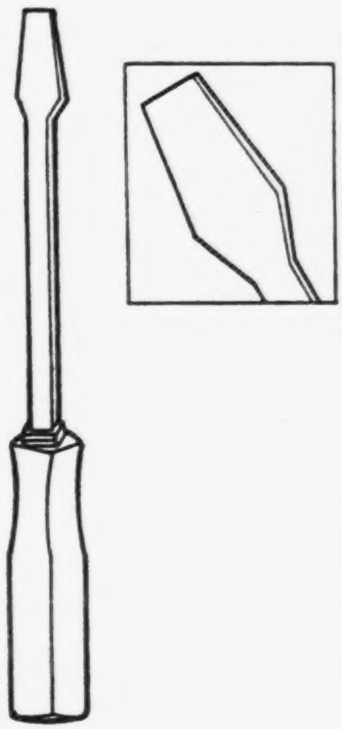


Figure 1-4 Round shank, no bolster

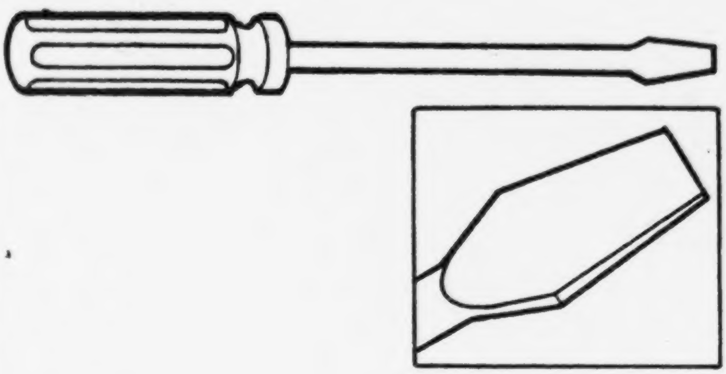
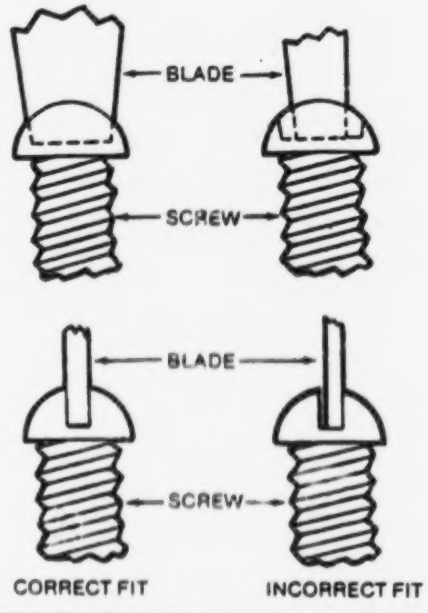


Figure 1-5 Correct and incorrect blade fit

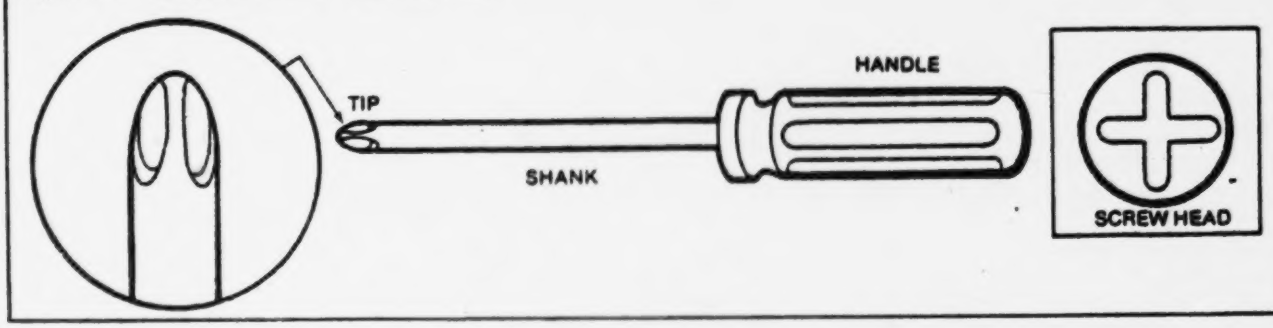


A worn or chipped standard screwdriver can be restored to its original shape by regrinding the tip. This is called ***redressing***. The easiest way to regrind a screwdriver is on a bench grinder, but the best way to do it is to file the screwdriver tip while you hold the screwdriver in a bench vise. This procedure does not heat the blade, which can remove the hardness from the tip.

Phillips Screwdriver

The Phillips screwdriver has a special blade tip. This blade tip is designed to fit into a Phillips screw (see Figure 1-6). Notice that a Phillips screw has two slots that cross at the center and do not extend to the edge of the head. As a result, the tip of the screwdriver cannot easily slip out of the head of the screw.

Figure 1-6 Phillips screwdriver and screw head

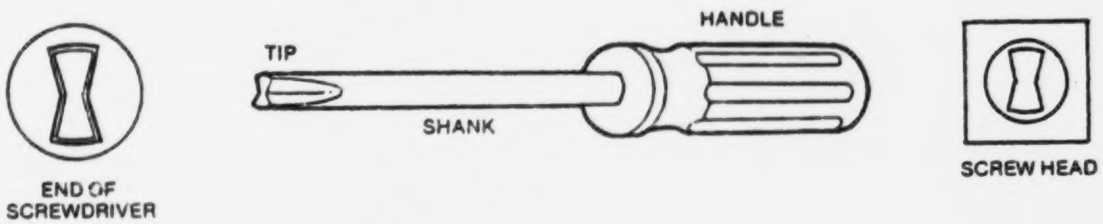


When you use a Phillips screwdriver, make sure you clean out the slots in the screw head. Also make sure you push down with more pressure against the screw head than you would with a standard screw and screwdriver.

Clutch-Head Screwdriver

Clutch-head screwdrivers are used with clutch-head screws. These screws are also called ***figure-eight*** or ***butterfly*** screws. Like the Phillips screws, clutch-head screws are designed to prevent the tip of the screwdriver from slipping out of the screwhead (see Figure 1-7).

Figure 1-7 Clutch-head screwdriver and screw head



Pliers

Pliers are tools which are used to grip, cut, crimp, and bend automotive parts. Each type of pliers performs a different task.

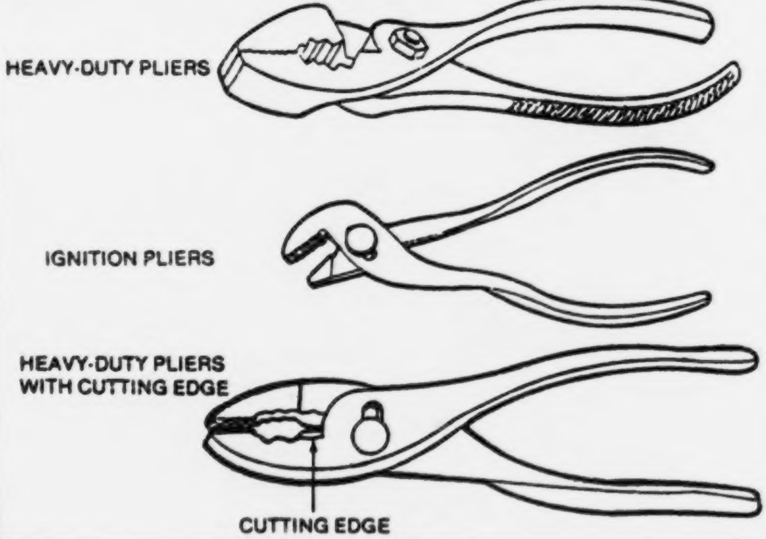
Like screwdrivers, pliers are widely used and often abused. Never use pliers on a nut or a bolt head because pliers will round off the shoulders of the nut or bolt.

There are four types of pliers in a basic hand tool set: combination slip-joint pliers, interlocking slip-joint pliers, cutting pliers, and needle-nose pliers.

Combination Slip-Joint Pliers

Combination slip-joint pliers are the most commonly used of all gripping pliers. The slip-joint permits the jaws to open wider to grip large objects. Sometimes slip-joint pliers have a cutting edge. The size of a pair of pliers is determined by its length, which may be from 4 1/2 to 8 inches. Figure 1-10 shows three types of combination slip-joint pliers.

Figure 1-10 Combination slip-joint pliers



Interlocking Slip-Joint Pliers

Interlocking slip-joint pliers, also called ***channel-lock pliers*** or ***water-pump pliers***, are used for gripping. The pliers have interlocking slots in the slip joint to keep them from slipping out of adjustment (see Figure 1-11). The jaws can be set to various widths to provide good grip and leverage.

Cutting Pliers

There are several types of cutting pliers used in automotive repairs. The most widely used are diagonal cutters, usually called ***dikes*** or ***side-cutters*** (see Figure 1-12). Light-duty dikes are small pliers used for cutting wire. Heavy-duty dikes are used for cutting heavy objects, such as cotter pins.

Figure 1-11 Interlocking slip-joint pliers

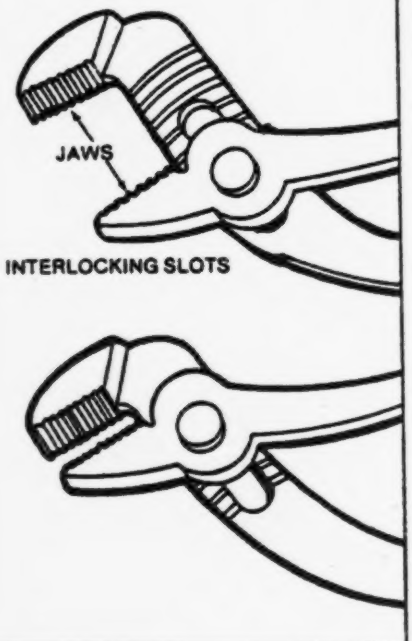
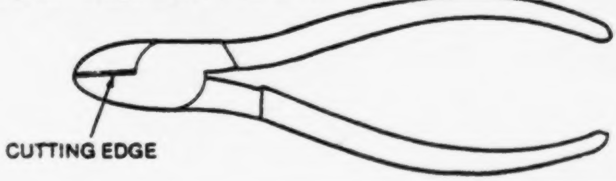


Figure 1-12 Diagonal cutters (dikes)

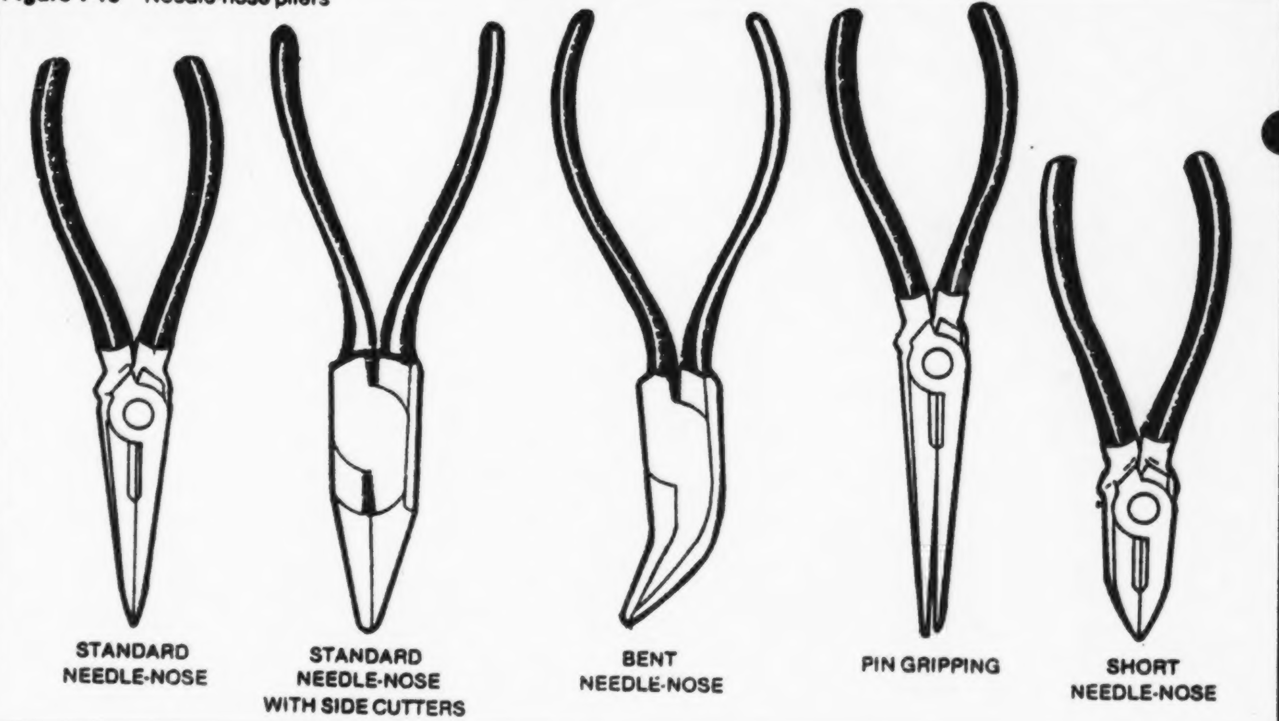


Needle-Nose Pliers

Needle-nose pliers are designed to hold and position small objects and to reach into restricted areas. They are sometimes equipped with side-cutters for cutting wire. Be careful when you use needle-nose pliers, especially the long, slim kinds, because it is very easy to break the jaws or to loosen the jaw alignment.

Figure 1-13 shows various types of needle-nose pliers used by mechanics.

Figure 1-13 Needle-nose pliers


STANDARD NEEDLE-NOSE
STANDARD NEEDLE-NOSE WITH SIDE CUTTERS
BENT NEEDLE-NOSE
PIN GRIPPING
SHORT NEEDLE-NOSE

All-Purpose Snips

All-purpose snips are available in many sizes and shapes. Two of the most commonly used kinds of snips are shown in Figure 1-76.

Hose-Clamp Pliers

Hose-clamp pliers are used to remove spring-type wire clamps. Figure 1-77 shows hose-clamp pliers being used to fasten a wire clamp in place. Notice that the wire clamp fits into the grooves of the jaws.

Battery Cable Pliers

There are several kinds of battery cable pliers. Figure 1-78 shows battery cable pliers used for general battery work (A), and battery cable pliers used to spread and clean battery terminal clamps (B).

Spark Plug Pliers

Spark plug pliers are specially insulated so that you can remove spark plug wires while the engine is running. Figure 1-79 shows spark plug pliers.

Figure 1-76 Aviation snips (A) and straight-cut snips (B)

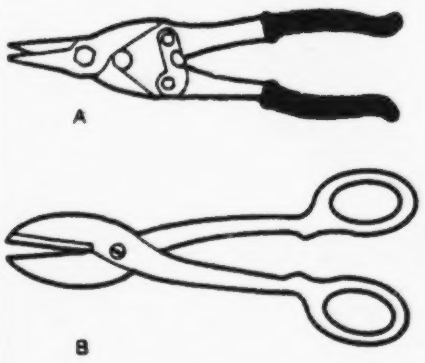


Figure 1-77 Fastening a wire clamp with hose-clamp pliers

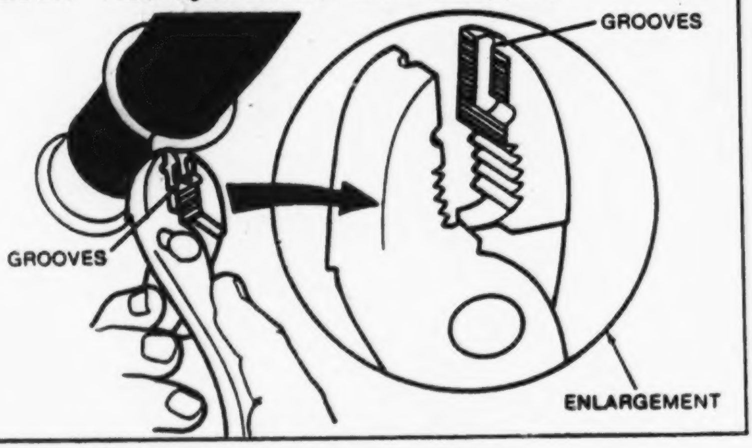


Figure 1-78 Battery cable pliers

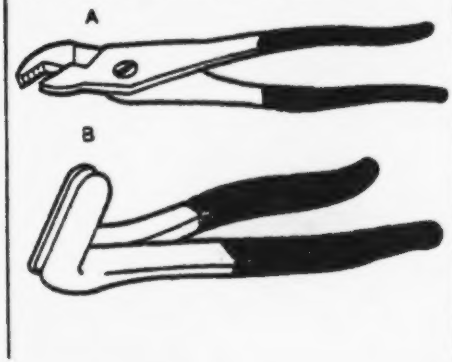
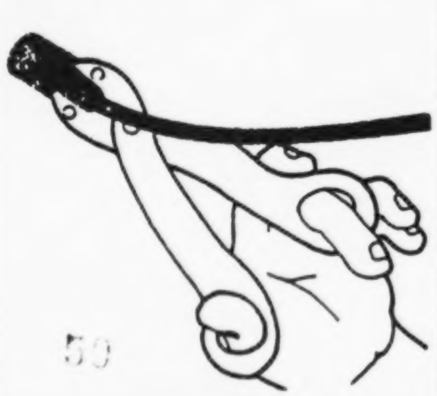


Figure 1-79 Spark plug pliers



PUNCHES

Marine mechanics use punches to drive out pins and shafts to align holes in two or more parts during assembly, and to mark the location of holes for drilling. Figure 1-14 shows a punch head and tip.

Punches must be redressed (reground) after they have been in use for a long time. The tip usually needs only a slight redressing, but the head may need much regrinding to put it back into a safe condition.

CAUTION:

Never use a punch that is not in good condition. Mushroomed heads (see Figure 1-15), or heads that have been poorly reground, can cause chips to fly up and hit you in the eye.

As an marine mechanic, you will be using at least four different puches: center punch, starter punch, pin punch, and long-tapered punch (alignment punch).

Figure 1-14 Punch

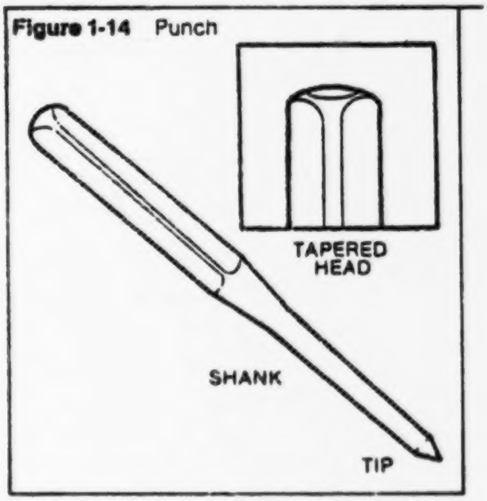
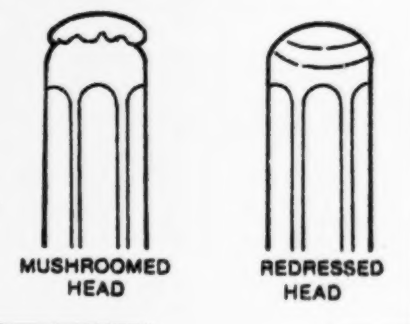


Figure 1-15 Punch heads



PUNCHES

Marine mechanics use punches to drive out pins and shafts to align holes in two or more parts during assembly, and to mark the location of holes for drilling. Figure 1-14 shows a punch head and tip.

Punches must be redressed (reground) after they have been in use for a long time. The tip usually needs only a slight redressing, but the head may need much regrinding to put it back into a safe condition.

CAUTION:

Never use a punch that is not in good condition. Mushroomed heads (see Figure 1-15), or heads that have been poorly reground, can cause chips to fly up and hit you in the eye.

As an marine mechanic, you will be using at least four different puches: center punch, starter punch, pin punch, and long-tapered punch (alignment punch).

Figure 1-14 Punch

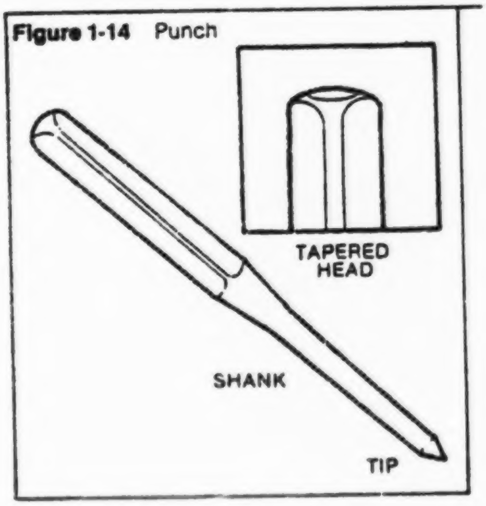
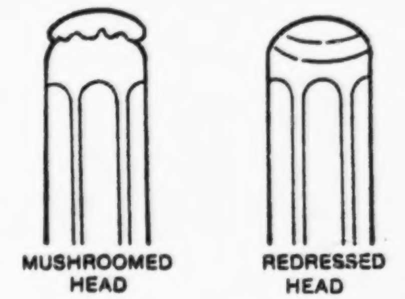


Figure 1-15 Punch heads



Center Punch

When you want to drill holes in metal, you will find the center punch useful for marking the location of the hole. Place the center punch where you want the hole to be. Then, tap the punch with a brass or ball peen hammer. This will make a small dent. The drill bit can now easily take hold in the metal (see Figure 1-16).

Starter Punch

The starter punch is used to help you get a pin, rivet, or bolt started out of a tight hole. Notice in Figure 1-17 that the shank tapers down to a flat tip.

Pin Punch

The pin punch has a straight shank. It is used for driving a pin, rivet, or bolt from the hole once it has been started. Notice that the shank of the pin punch is not tapered (see Figure 1-18). A pin punch must always be slightly smaller than the object you are driving out.

Figure 1-16 Using a center punch to make a hole for a drill bit

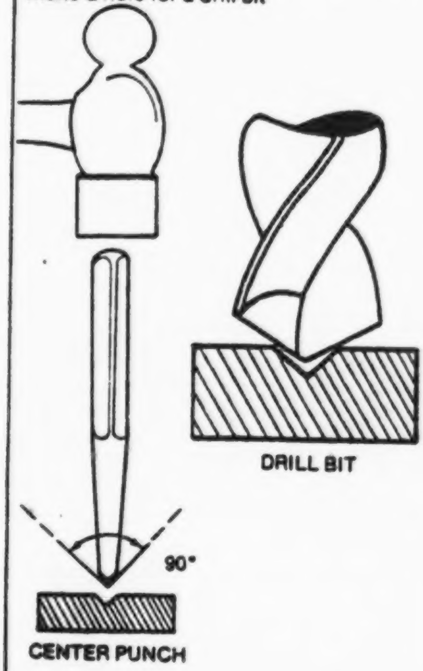


Figure 1-17 Using a starter punch to start a pin out of a tight hole

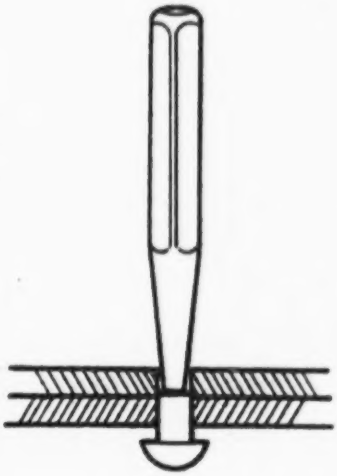
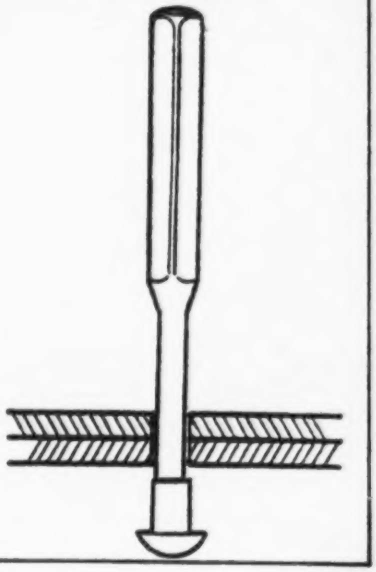


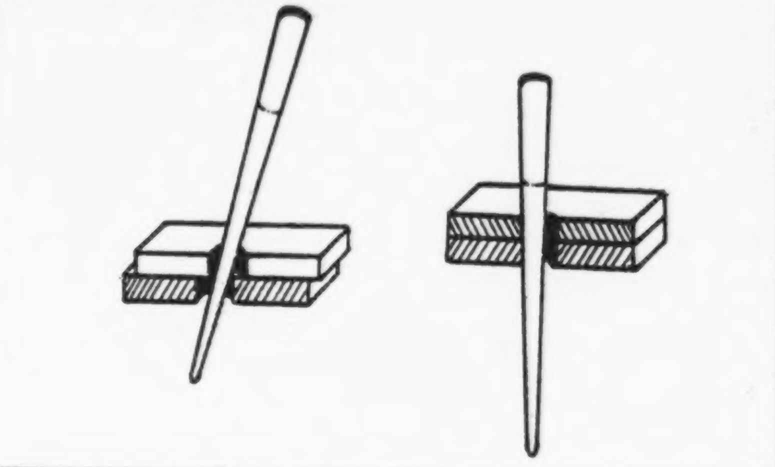
Figure 1-18 Using a pin punch to drive a pin out of a tight hole



Long-Tapered Punch (Alignment Punch)

The long-tapered punch is used for aligning the holes of two or more parts. The punch is inserted through the holes and pulled or wiggled into an upright position to align the holes (see Figure 1-19).

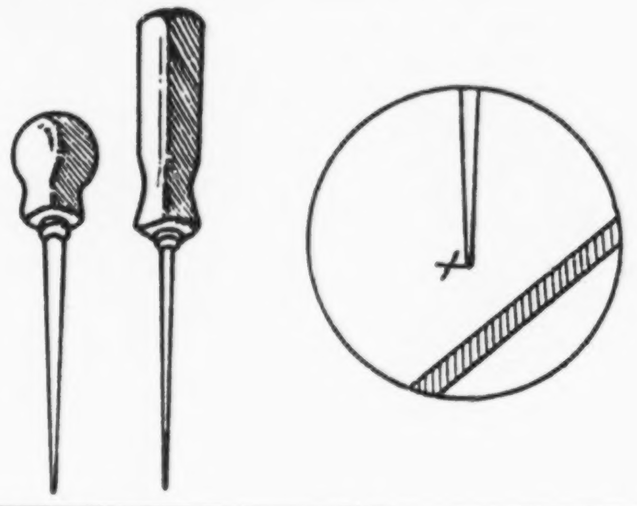
Figure 1-19 Long-tapered punch



Scratch Awl

The scratch awl is used to scribe or scratch marks in metal (see Figure 1-20). The point is made of hardened steel. Do not use the scratch awl for any other purpose than scribing.

Figure 1-20 Scratch awl



CHISELS

Chisels are used by marine mechanics to cut sheet metal, to cut off rivet heads and bolt heads, and to split rusted or rounded nuts. Figure 1-21 shows a chisel head.

Chisels are made of tough steel alloys. The cutting edge of a chisel is heat-treated for hardness. The heads are specially treated so that they will not be brittle. This prevents chipping of the heads. Chisels also have a taper to reduce the mushrooming caused by heavy blows with a hammer.

Chisels, like punches, must be maintained by occasional redressing (regrinding).

Chisels vary according to the type of edge they have. You will be using the following types of chisels: flat chisel, cape chisel, round-nose chisel, and diamond-point chisel.

CAUTION: Always wear safety glasses when working with chisels.

Figure 1-21 Chisel head

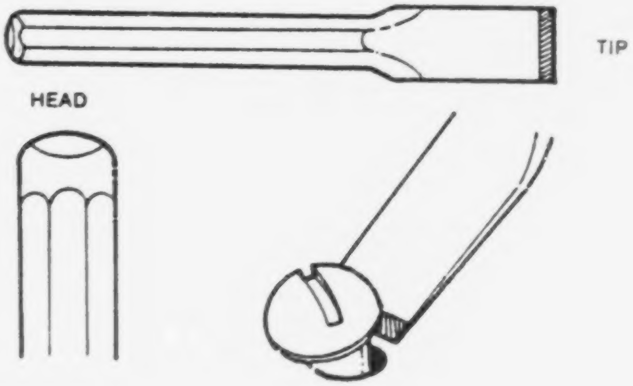
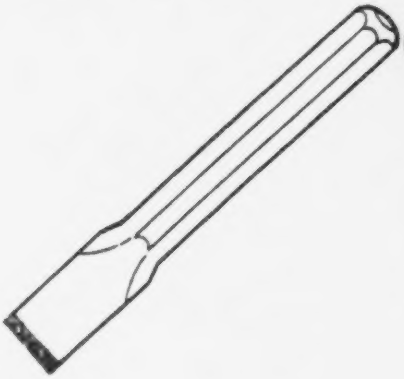


Figure 1-22 Flat chisel



FLAT CHISEL

The flat chisel (see Figure 1-22), also known as a cold chisel, is used to cut metal, to cut the heads from rivets, and to split rusted nuts. It has a straight cutting edge, and its size is determined by the width of the edge.

Cape Chisel

The cutting edge of the cape chisel is V-shaped and is narrower than that of the flat chisel (see Figure 1-23). It is used for cutting keyways, narrow grooves, and square corners. It is also used to cut off rivet heads or to alter threads on a bolt so that the nut will not shake loose.

Round-Nose Chisel

The round-nose chisel (see Figure 1-24) has a rounded or curved cutting edge. It is used inside rounded corners or to cut circular grooves.

Diamond Point Chisel

The diamond point chisel (see Figure 1-25) has a diamond-shaped cutting tip. It is used for cutting sharp corners or for making V-cuts.

Figure 1-23 Cape chisel

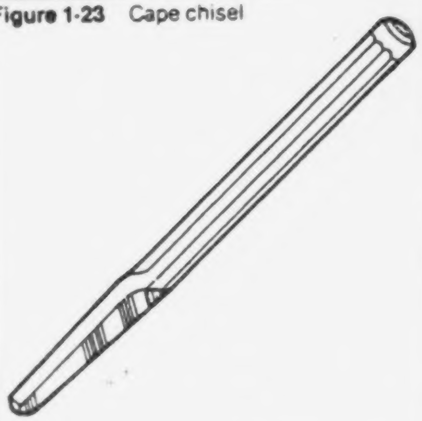


Figure 1-24 Round-nose chisel

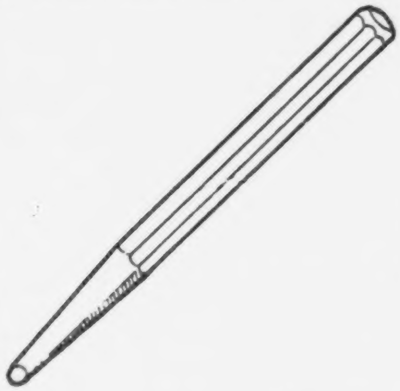
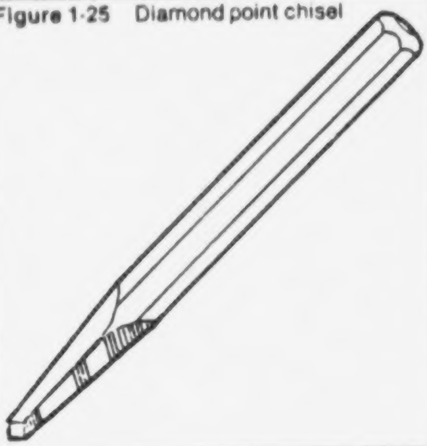


Figure 1-25 Diamond point chisel



HAMMERS

Marine mechanics must use hammers safely. Also, they must know the different kinds of hammers and their uses.

You should always check to see if the hammer head is attached securely to the handle. Also, make sure you never strike a steel surface with a steel-headed hammer. Particles of steel may break loose and cause eye injuries or other wounds.

A hammer should be held properly, too. You should always grasp a hammer near the end of the handle. Check your aim by tapping the object to be hammered once or twice before you strike it firmly.

BALL PEEN HAMMER

The ball peen hammer (see Figure 1-26) is a steel hammer with a striking head on one end and a rounded face (ball peen) on the opposite end. This hammer is used for general work, for driving chisels, and for bending and shaping the end of a pin to form a rivet head.

CROSS PEEN HAMMER

The cross peen hammer (see Figure 1-27) has a wedge-shaped peen head on one end and is flat on the other end. It is used for general work and for shaping metal.

Figure 1-26 Ball peen hammer

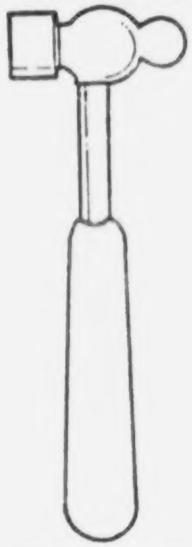


Figure 1-27 Cross peen hammer

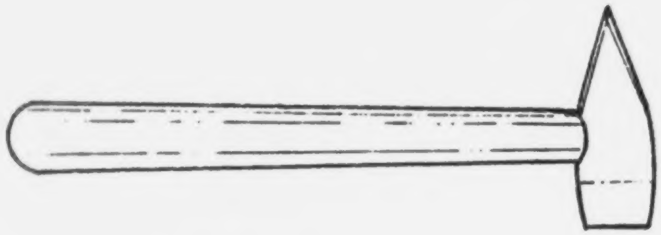


Figure 1-28 Brass hammer

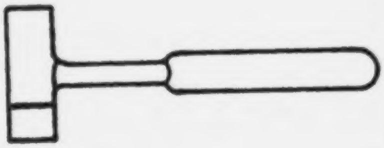


Figure 1-29 Plastic tip hammer

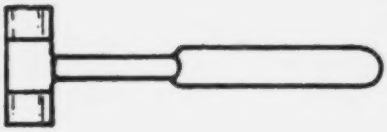


Figure 1-30 Soft face hammer

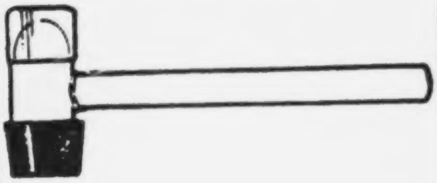
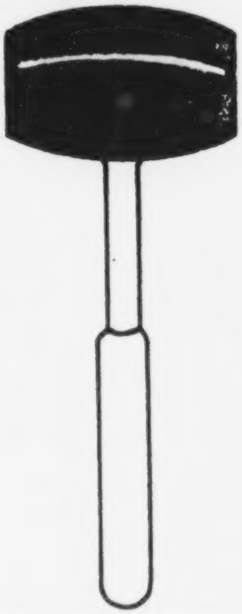


Figure 1-31 Rubber mallet



Brass Hammer

The brass hammer (see Figure 1-28) has a soft, flat head. It is heavy and is used for driving gears and shafts. Also, it is used for driving heavy metal parts that must not be damaged.

Plastic Tip Hammer

The plastic tip hammer (see Figure 1-29) has a flat, plastic tip on both ends of the head. This hammer is used for driving light objects that must not be damaged.

Soft Face Hammer

The soft face hammer (see Figure 1-30) has a flat hitting surface that yields when striking an object. One end has a rubberlike tip of medium hardness. The other end is made of hard nylon.

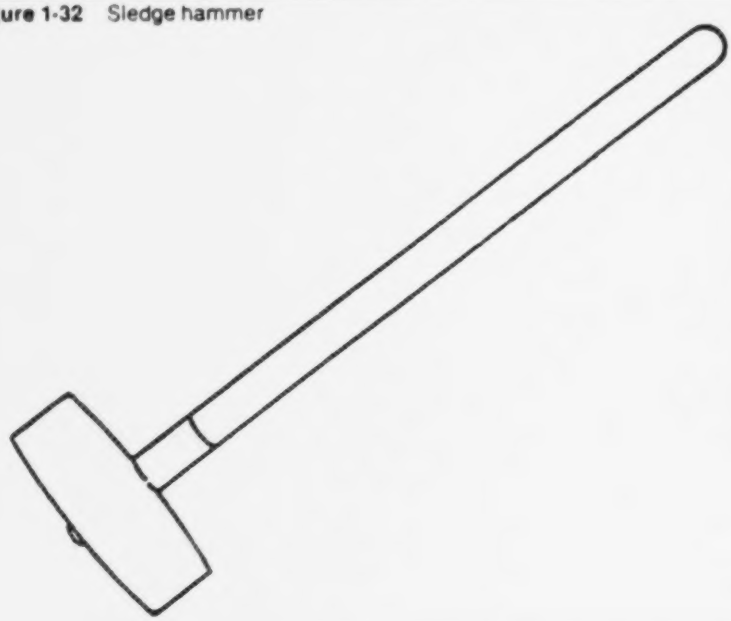
Rubber Mallet

The head of the rubber mallet (see Figure 1-31) is made from high-grade rubber. It is primarily used for tire repair work.

Sledge Hammer

The sledge hammer (see Figure 1-32) is used for very heavy work and has a flat surface on both ends.

Figure 1-32 Sledge hammer



Wrenches

Wrenches are used to turn nuts and bolts. Wrench sizes vary depending on the use and type of wrench. The size of the wrench is stamped on the handle. The size shown is the size of the bolt head or nut, *not* the bolt thread diameter. For example, a 3/8-inch bolt usually has a head that is 9/16 inch wide (see Figure 1-33). Therefore, you would need a 9/16-inch wrench to fit around the nut.

Always make sure you select the correct wrench size. Otherwise, you may damage the nut, bolt head, or wrench jaws. Figure 1-34 shows the proper way to place an open-end wrench on a bolt.

Figure 1-33 3/8-inch bolt takes 9/16-inch wrench

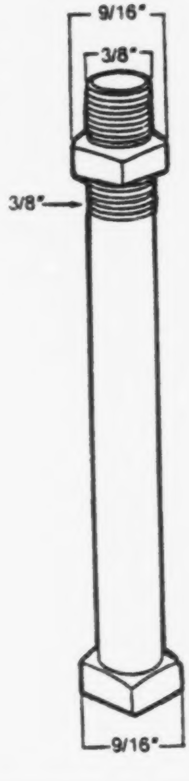


Figure 1-34 Wrench placed on bolt

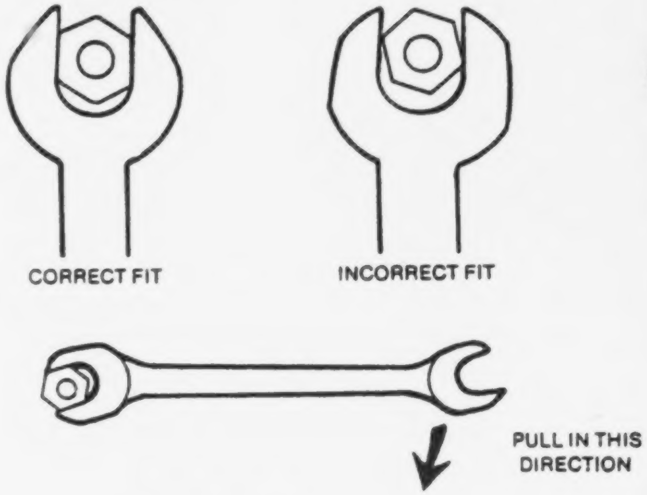
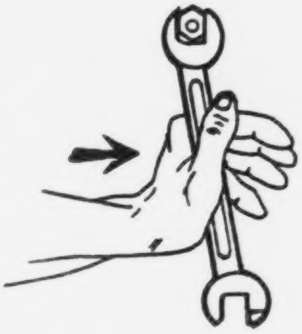


Figure 1-35 Correct way to push an open-end wrench



When applying force, always pull the wrench toward you, if possible. If you must push the wrench, push it carefully (see Figure 1-35). ***Always use the palm of your hand with the fingers outstretched to avoid injuring your fingers in case the wrench slips.***

You will be using many types of wrenches in automotive mechanics. Some of these are:

- standard open-end wrench
- midget or ignition open-end wrench
- angle head open-end wrench
- box wrench
- combination wrench
- flex-head wrench
- half moon box-end wrench
- ratcheting box wrench
- flare nut wrench

Standard Open-End Wrench

The standard open-end wrench has an opening at each head. The openings at either end are of different sizes. The open heads of the wrench allow the wrench to be slipped on and off nuts and bolts easily (see Figure 1-36).

Figure 1-36 Standard open-end wrench

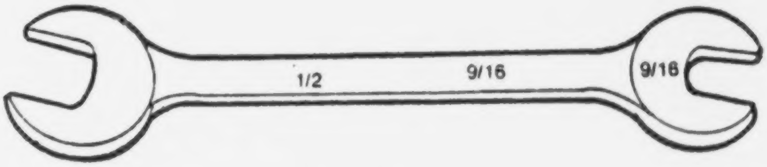
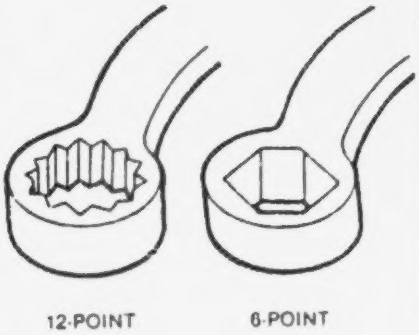


Figure 1-37 Box wrench showing 12- and 6-point openings



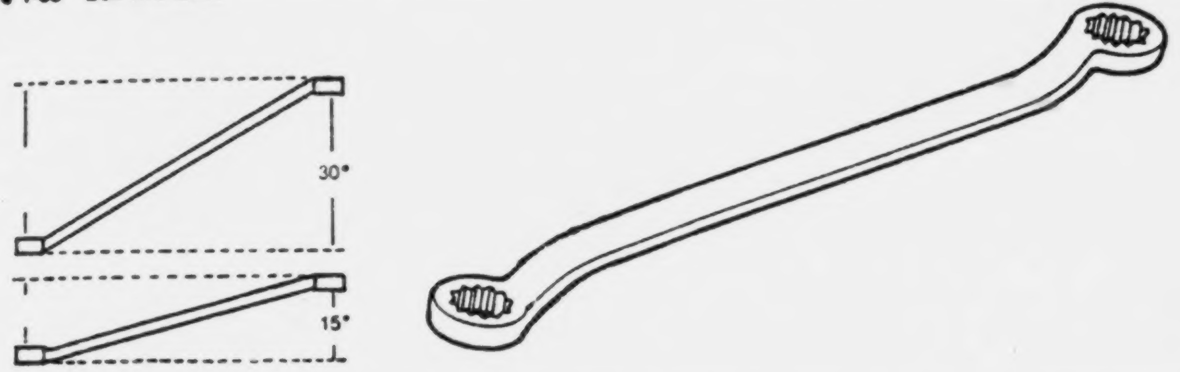
Box Wrench

One of the safest wrenches to use is the box wrench because its head completely surrounds the nut or bolt (see Figure 1-37).

That means it will slip less than any open-end wrench. The openings are either 12 points (double hex) or 6 points (hex) A 12-point wrench can be positioned on a bolt more quickly.

A 6-point wrench is used when the nut is rounded or rusted. The heads of box wrenches are offset either 15 degrees or 30 degrees (see Figure 1-38).

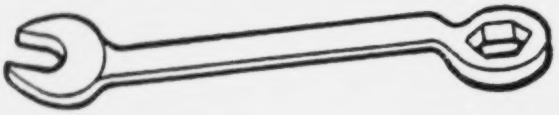
Figure 1-38 Box wrenches



Combination Wrench

The combination wrench (see Figure 1-39) has a box wrench on one end and an open-end wrench on the other. Both ends are offset 15 degrees from the handle, making the wrench easier to use. The openings are the same size on both ends. The box end is used to break loose a nut or bolt. The open end permits fast removal of the nut or bolt.

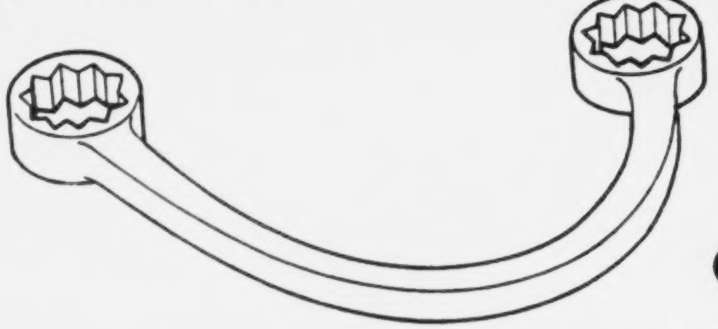
Figure 1-39 Combination wrench



Half Moon Box-End Wrench (Starter Wrench)

The half moon box-end wrench is used to remove a bolt when something is in your way (see Figure 1-40). Each end on the half moon box-end wrench has a different size opening.

Figure 1-40 Half moon box-end wrench



Ratcheting Box Wrench

A ratcheting box wrench (see Figure 1-41) is used to help you remove a nut quickly where space is limited. Also, it is used when long threads prevent the use of a socket. Because these wrenches are shorter, you can get a good fit with limited handle movement (see Figure 1-42). This wrench has a different size opening on each end.

Figure 1-41 Ratchet box wrenches

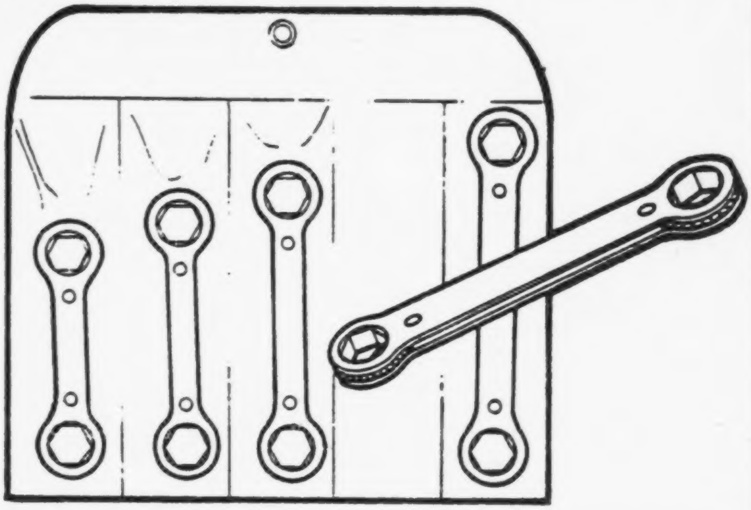
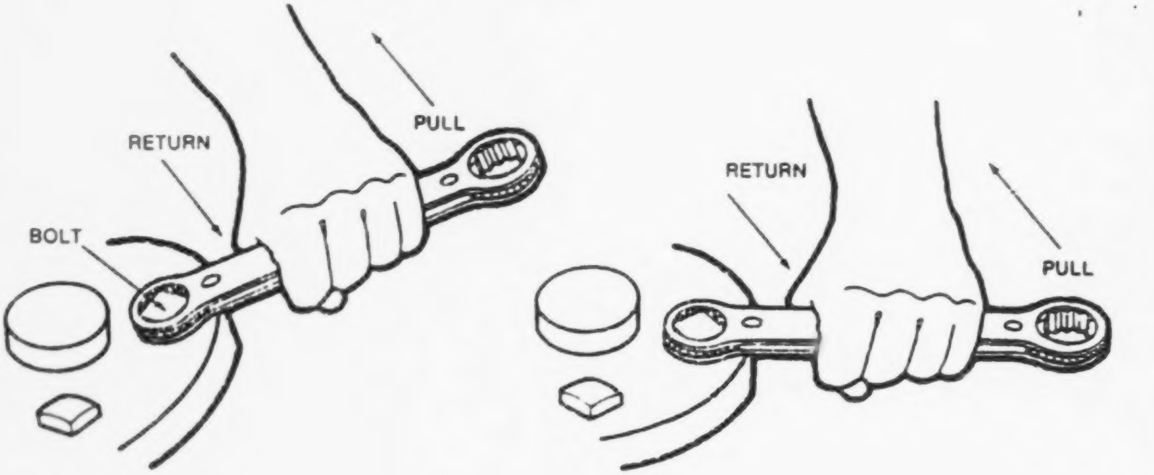


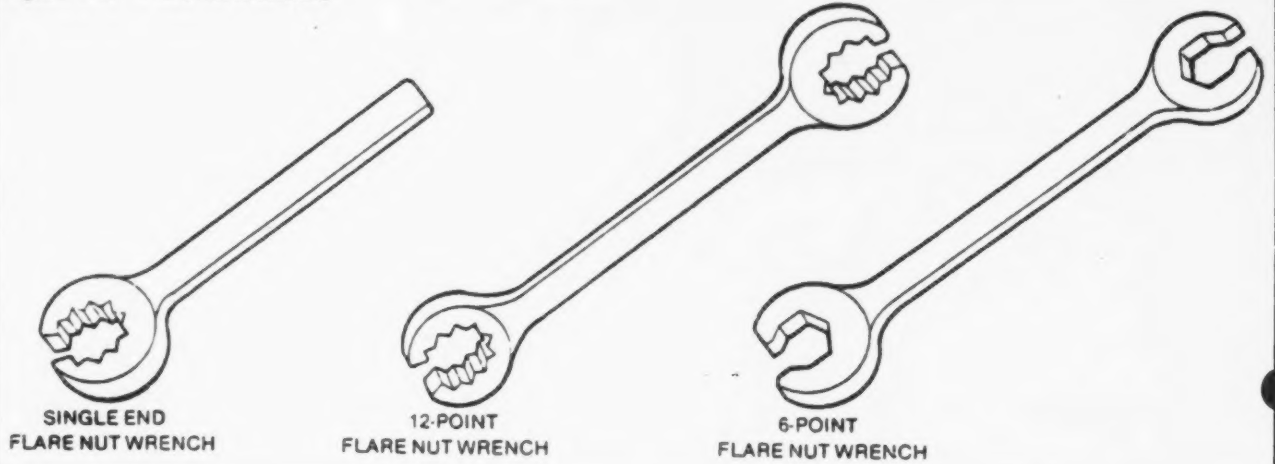
Figure 1-42 Removing and tightening a bolt, using a ratcheting box wrench



Flare Nut Wrench

The flare nut or line wrench is like a box wrench with the end cut out (see Figure 1-43). It is used to remove line fittings. It gives a better grip on the fittings, and helps prevent the rounding off of brass fittings.

Figure 1-43 Flare nut wrenches


SINGLE END
FLARE NUT WRENCH
12-POINT
FLARE NUT WRENCH
6-POINT
FLARE NUT WRENCH

Socket Wrenches and Handles

Sockets

Sockets are heads used to loosen nuts and bolts. The handles (drives) attach to the sockets. Sockets usually do not slip off the nut or bolt.

Sockets are measured by socket size and drive end opening. For example, a 1/4-inch drive socket has an opening 1/4-inch wide (see Figure 1-44). The drive-end opening is where the socket snaps onto the handle or driver.

Like box wrenches, sockets usually have 6 or 12 points. The 6-point socket is used when the nut is rounded or rusted.

Figure 1-44 Socket and drive sizes

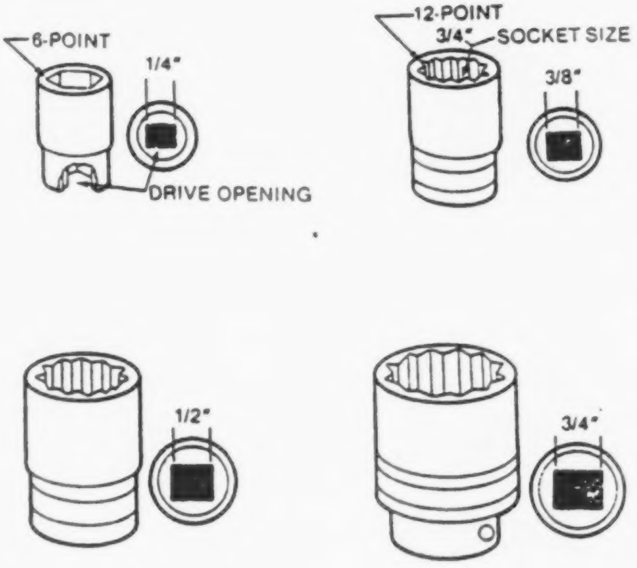


Figure 1-45 4-point and 8-point sockets

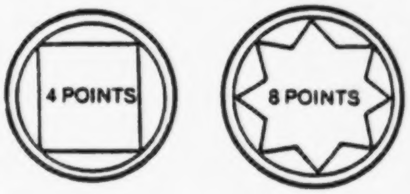


Figure 1-46 Deep well socket

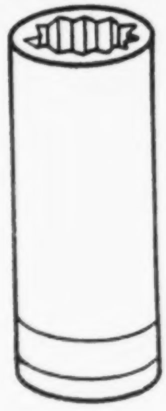


Figure 1-47 Drive adapter

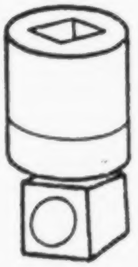
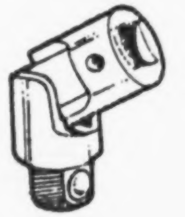


Figure 1-48 Universal joint



Some sockets have 4 points or 8 points. These sockets are used to loosen square nuts and bolts (see Figure 1-45).

Standard and Deep Well Sockets

The standard socket fits nuts that do not have an extended bolt through them. You must use a deep well socket for nuts that have a bolt extended through them (see Figure 1-46).

Special Sockets or Adapters

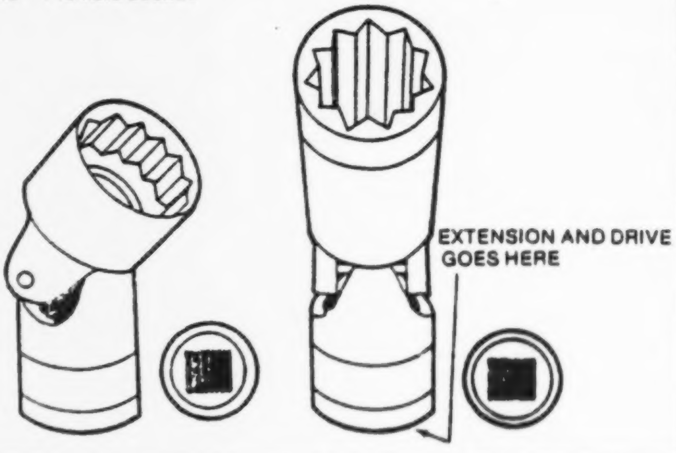
There are several types of special sockets that are used in automotive repair work. Each is designed for a specific purpose, and should be used only for that job.

A *drive adapter* is used to change the the size of the drive (handle) to sizes between 1/4 and 3/4 inch (see Figure 1-47).

The universal joint enables you to turn nuts where there is no room for a straight wrench (see Figure 1-48).

The flexible socket is a combination socket and universal joint. It is used when a bolt or nut can only be reached at an angle (see Figure 1-49).

Figure 1-49 Flexible socket



The crowfoot is designed to help you loosen a nut or bolt from the side when you cannot reach it from the top (see Figure 1-50).

Figure 1-50 Crowfoot

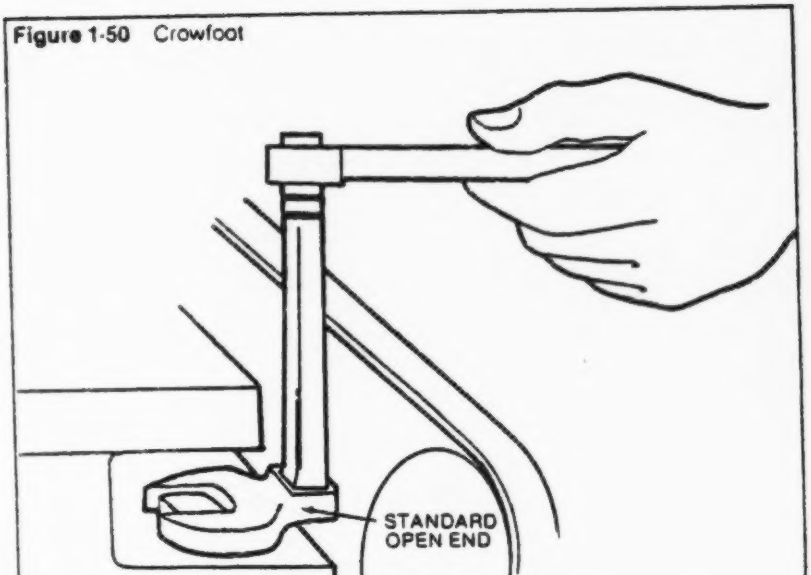
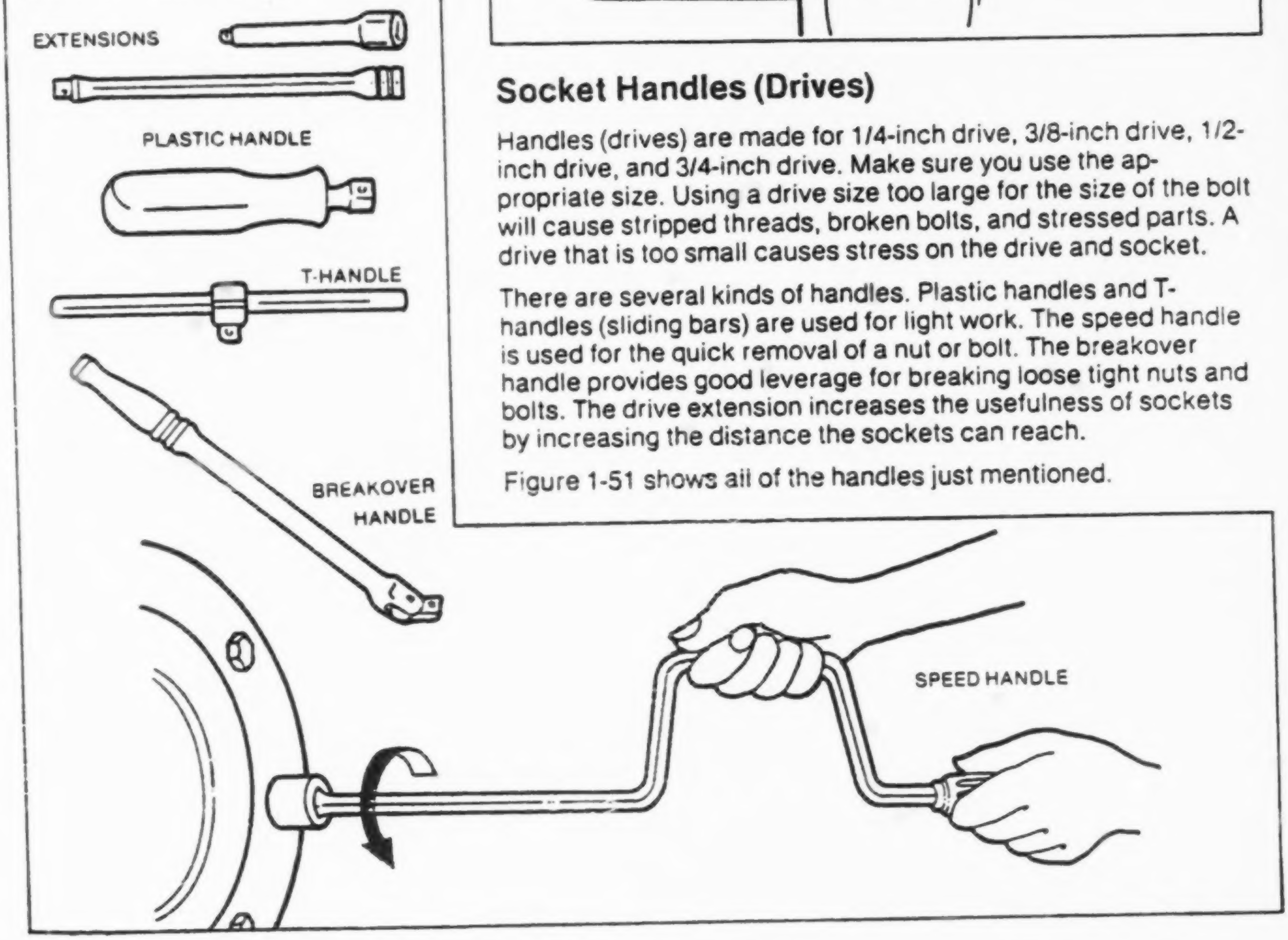


Figure 1-51 Socket handles



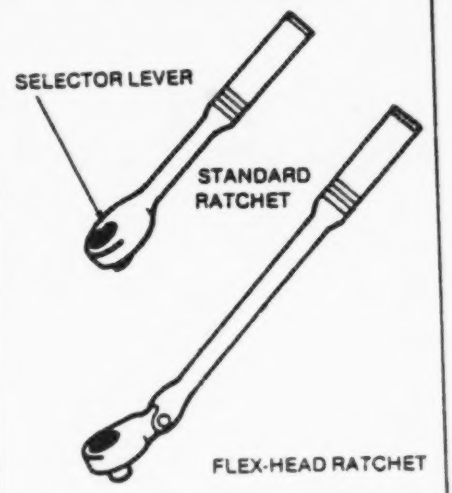
Socket Handles (Drives)

Handles (drives) are made for 1/4-inch drive, 3/8-inch drive, 1/2-inch drive, and 3/4-inch drive. Make sure you use the appropriate size. Using a drive size too large for the size of the bolt will cause stripped threads, broken bolts, and stressed parts. A drive that is too small causes stress on the drive and socket.

There are several kinds of handles. Plastic handles and T-handles (sliding bars) are used for light work. The speed handle is used for the quick removal of a nut or bolt. The breakover handle provides good leverage for breaking loose tight nuts and bolts. The drive extension increases the usefulness of sockets by increasing the distance the sockets can reach.

Figure 1-51 shows all of the handles just mentioned.

Figure 1-52 Two types of ratchets


SELECTOR LEVER
STANDARD RATCHET
FLEX-HEAD RATCHET

Ratchets are also drive handles for sockets. The ratchet allows you to turn the socket in either direction. Figure 1-52 shows 2 different types of ratchets. Sockets are attached to ratchets to remove and install bolts and nuts. A selector lever on the ratchet allows you to reverse directions from clockwise to counterclockwise.

Hacksaws

Hacksaws are used to cut metal and plastic. A hacksaw consists of two main parts: the frame and the blade (see Figure 1-55). Notice that the teeth of the blade always point toward the front of the frame.

The blade is removed and replaced by loosening the wing nut on the back side of the frame and lifting the blade off the frame (see Figure 1-56).

Figure 1-55 A typical hacksaw

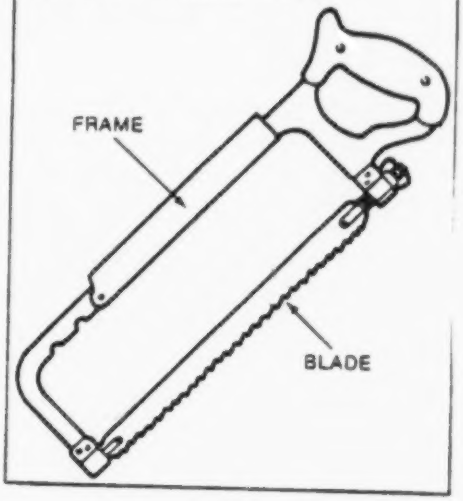
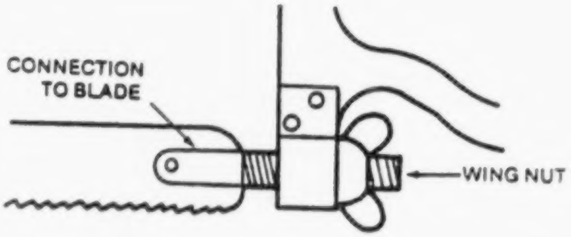


Figure 1-56 Wing nut used to loosen the blade



Almost all hacksaws are adjustable so that different lengths of blades can be used. The common sizes of blade lengths are 8 inches, 10 inches, and 12 inches.

Hacksaw blades also have different numbers of teeth per inch. In automotive work, the 18-tooth and 32-tooth blades are most common. This means that for every inch of blade, there are 18 saw teeth per inch (see Figure 1-57).

The 18-tooth blade is used for general-purpose sawing. The 32-tooth blade is used for sawing thin sheet metal or thin tubing.

Replacing a Hacksaw Blade

After selecting the correct blade for the job you are doing, install the blade on the hacksaw.

First, adjust the length of the frame to the length of the blade. If you are using a 12-inch blade, the frame must be 12 inches long. This adjustment is made at point A in Figure 1-58.

Next hook the blade on the pin at the front of the frame at point B. Then hook the blade on the pin at the back of the frame at point C. Finally, tighten the wing nut until the blade is rigid in the frame, as shown in Figure 1-59.

Figure 1-57 18 and 32 teeth per inch blades

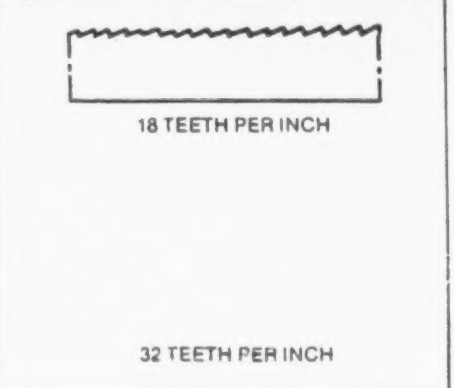


Figure 1-58 Installing a blade

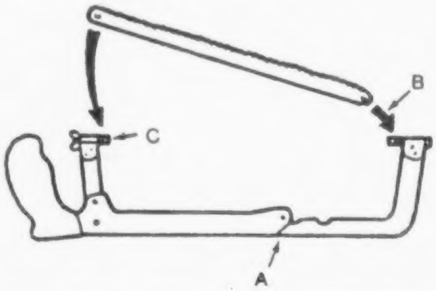
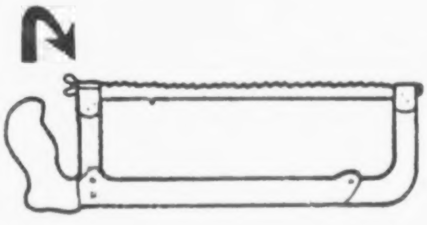


Figure 1-59 Tightening a blade



Sawing with a Hacksaw

Sawing with a hacksaw must be done correctly to prevent damage to both the blade and the material being cut. The following points should be followed when you use a hacksaw:

1. If you put material in a vise to be cut, always cut as close as you possibly can to the jaws of the vise. A rule of thumb is to place the point of the cut to within 1/4 inch of the vise jaws, as shown in Figure 1-60.
2. If possible, hold the hacksaw with both hands while sawing (see Figure 1-60).
3. Do not start a cut with a deep angle. Keep the saw as level as possible as you start the cut (see Figure 1-61).
4. Start the cut by holding the blade lightly on the work. Use the entire length of the blade on each stroke.
5. If the metal is very hard, use slow cutting strokes. This prevents the blade from heating up and becoming dull and weak.
6. Never force a cut with heavy downward pressure or by pushing too hard during the cutting stroke. Too much pressure or force may break the blade.
7. Always wear eye protection when sawing with a hacksaw.

Figure 1-60 Proper method of sawing material in a vise

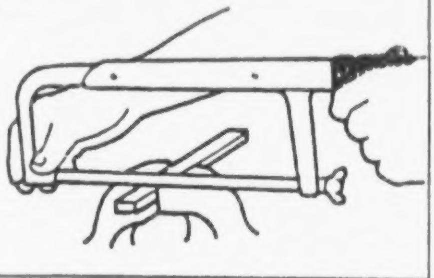
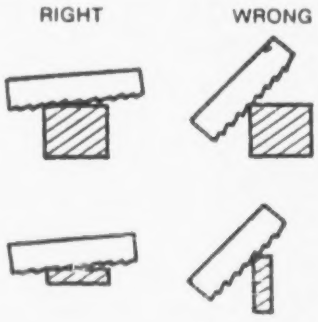


Figure 1-61 Starting the hacksaw cut



Parts Clean-Up Tools

Marine mechanics do many cleaning jobs, such as scraping gaskets and cleaning residue, grease, and oil from automotive parts and tools. Having a wide selection of clean-up tools makes the job easier and faster. The tools are listed here in two sections: scrapers and brushes.

Scrapers

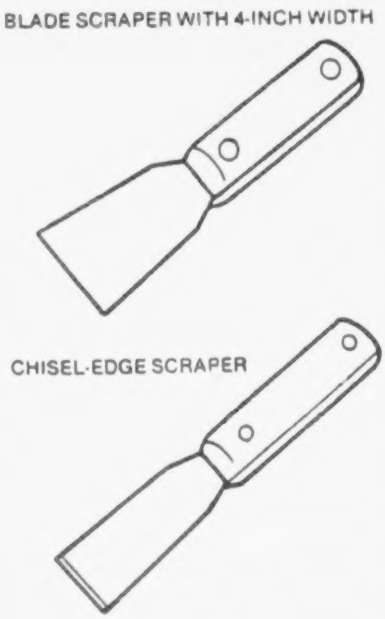
Scrapers have blades made from high-grade alloy steel. These blades are 1/2 inch to 5 inches wide. They may be flexible or stiff (see Figure 1-62).

Scrapers that become dull can be reground on a bench grinder, but filing the tip with a file while holding the scraper in a vise is the best method. This procedure does not heat the blade and remove the temper (hardness).

NOTE: If you regrind the blade on a bench grinder, observe all the safety rules that pertain to using a bench grinder. Remember these safety rules:

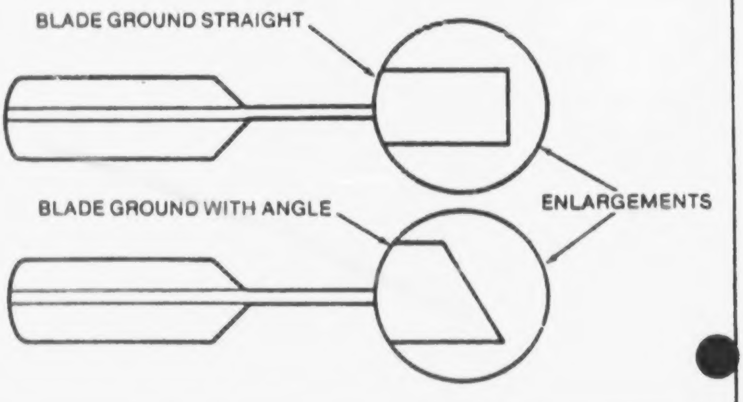
Use eye protection.
Wear appropriate clothing.
Do not wear jewelry.
Keep persons not wearing protective devices away from the work area.

Figure 1-62 Two types of scrapers



These blades can be ground in two ways: straight for scraping with either side of the blade, or on one side like a flat chisel (see Figure 1-63).

Figure 1-63 Scraper blades with straight and angled tips



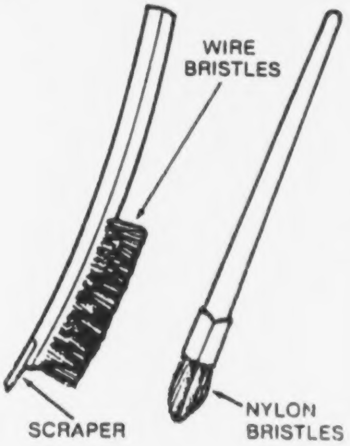
Brushes

Several types of brushes are used in marine work. Many of them are special-purpose brushes for specific jobs. The two brushes you will use the most in marine work are the standard wire brush and the parts cleaning brush shown in Figure 1-64.

The wire brush is used to remove rust, dirt, and corrosion from automotive parts. The bristles are made of stiff wire. Some wire brushes have a scraper attached to the front to help remove heavy corrosion, rust, or sealant residue. This brush is very useful in many areas of automotive work.

The parts cleaning brush is used with cleaning solvent to remove dirt, grease, oil, and other material from automotive parts. The bristles are usually made of stiff nylon to help loosen dirt and grease from the parts. Always use caution when cleaning parts with this brush. The bristles can cause solvent to flip into your eyes if not used properly.

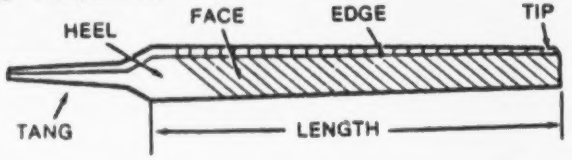
Figure 1-64 Wire and parts cleaning brushes



Files and Filing

The file is a cutting tool used to remove metal. The file is used for many reasons. It can remove burrs, dents, and nicks. Also, files are used to change the shape or size of objects. A file must be kept clean and dry. Its teeth must be protected when it is not in use. The names of the parts of a file are shown in Figure 1-65.

Figure 1-65 Parts of a file


FACE
EDGE
TIP
HEEL
TANG
LENGTH

NOTE: The length of a file is determined by measuring from the *heel* to the *tip.*

Mill File

The mill file is called a *single-cut* file which means the rows of cutting teeth run in one direction and are parallel to each other (see Figure 1-66).

The mill file is further classified by the degree of coarseness of the teeth. Figure 1-67 shows the tips of the files.

Figure 1-66 Mill file

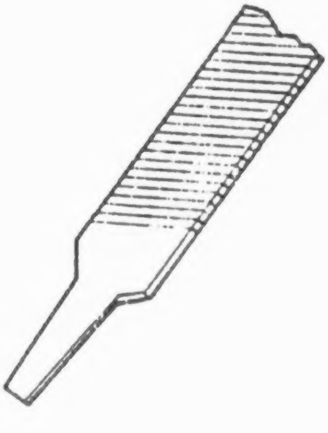
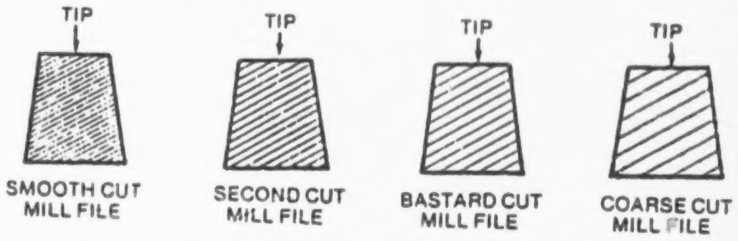


Figure 1-67 Types of file cuts


TIP
TIP
TIP
TIP
SMOOTH CUT MILL FILE
SECOND CUT MILL FILE
BASTARD CUT MILL FILE
COARSE CUT MILL FILE

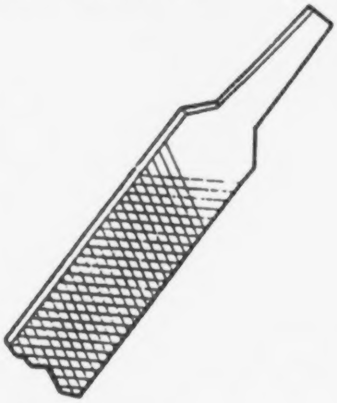
When selecting a file from the tool room, you ask for the file by size and type. For example, you might ask for a six-inch smooth cut mill file, a ten-inch bastard mill file, a twelve-inch coarse cut mill file, or any other combination of size and cut you need to do the job.

Double-Cut File

A double-cut file has double rows of teeth running at an angle to each other (see Figure 1-68).

Double-cut files are also classified as smooth cut, second cut, bastard cut, and coarse.

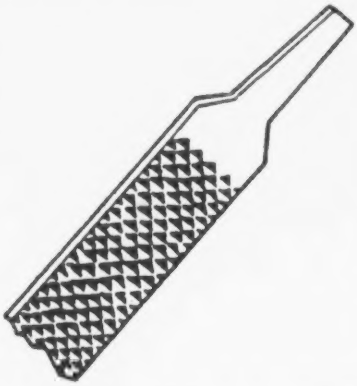
Figure 1-68 Double-cut file



Rasp Files

Rasp files have individual teeth and are used for cutting very soft materials such as wood, aluminum, and brass (see Figure 1-69).

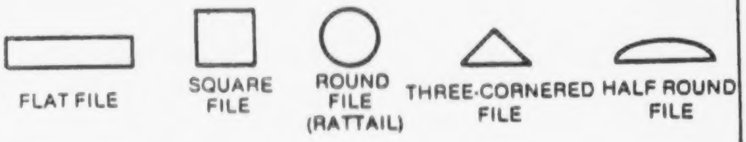
Figure 1-69 Rasp file



Shapes of Files

A file is also classified by its shape when viewed from the tip end of the file (see Figure 1-70).

Figure 1-70 Shapes of files

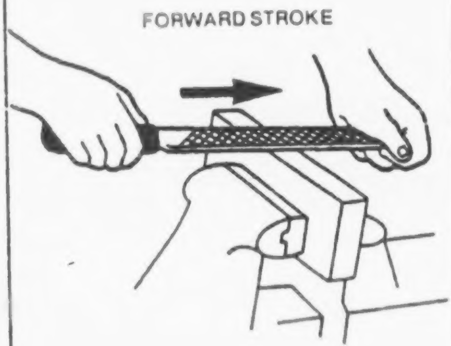


For example, you might ask for a 10-inch rat-tailed rasp file or a six-inch three-cornered smooth-cut mill file, or perhaps a ten-inch flat bastard-cut machinist file.

Filing Procedures

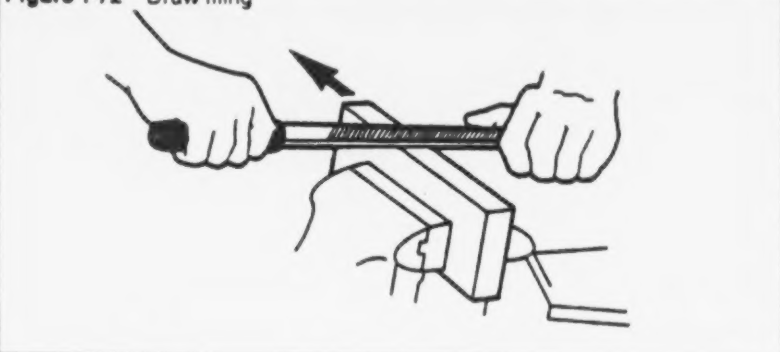
A file is designed to cut on the forward stroke only. It should be lifted from the work on the return stroke. Filing should be done at a rate of 40 to 60 strokes per minute. Always use a file handle when filing (see Figure 1-71).

Figure 1-71 Correct method of filing



When a very smooth finish is desired on a surface, you will sometimes use a single-cut file and pull the file toward yourself. This kind of filing is called draw filing (see Figure 1-72).

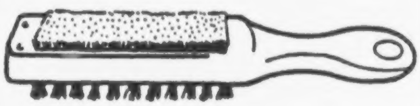
Figure 1-72 Draw filing



When a file becomes loaded with metal, you should clean it with a file card, also called a file cleaning brush (see Figure 1-73).

CAUTION: Never use a file as a pry bar. Never hit a file with a hammer. Files are hard and brittle and break very easily.

Figure 1-73 File card (file cleaning brush)



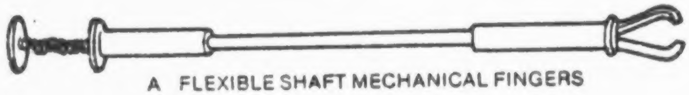
Pick-up Tools

There are two basic types of pick-up tools: magnetic and mechanical. Magnetic and mechanical pick-up tools are used as extensions to reach into hard-to-reach places.

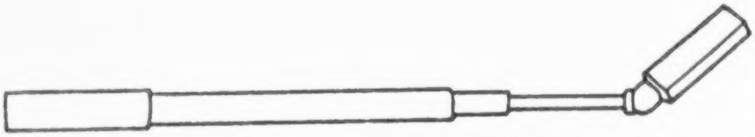
The magnetic pick-up has a strong permanent magnet attached to a handle. Most magnetic pick-ups have telescoping handles, and can lift up to several pounds.

The mechanical pick-up has a shaft which is both flexible and rigid. A mechanical jaw at one end opens approximately one inch. The jaw is controlled by a spring-loaded operating button (see Figure 1-74).

Figure 1-74 Two pick-up tools



A FLEXIBLE SHAFT MECHANICAL FINGERS



B HINGED-HEAD MAGNETIC PICKUP

Mirrors

Mirrors, such as the inspection mirror shown in Figure 1-80, are used with extension lights or flashlights. These mirrors allow you to look at areas that cannot ordinarily be seen easily. The inspection mirror is connected to a handle through a pivot so the mirror can be tilted. Mirrors are available in a variety of lengths and shapes.

Figures 1-81 and 1-82 show mirrors in use.

Figure 1-80 Round mirror with telescoping handle

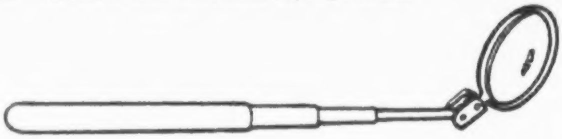


Figure 1-81 Using a mirror to inspect the inside of an engine crankcase

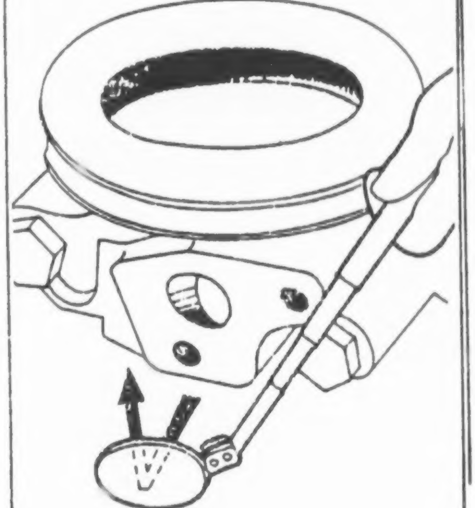
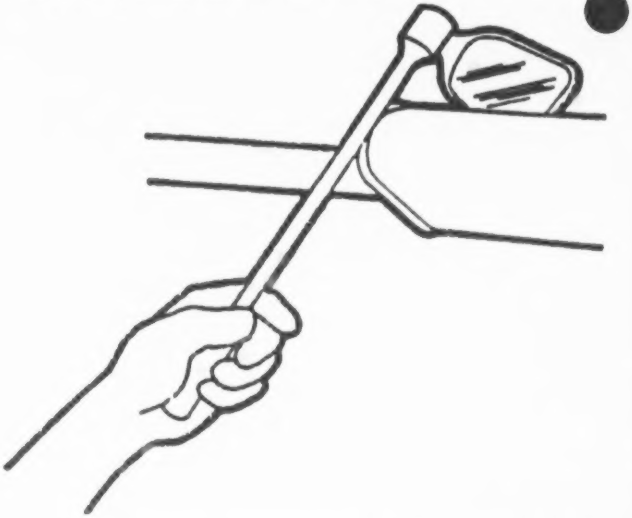


Figure 1-82 Inspecting the top of a muffler with a mirror



MODULE 02.02

USING POWER TOOLS **INSTRUCTOR GUIDE**

COMPETENCY:
Identify, use, and maintain electric and pneumatic power tools.

INSTRUCTIONAL OBJECTIVES:

The student will be able to:

1. Select according to task requirements, set up, maintain, and properly store the following electric power tools and accessories:
   - drill bits
   - drill motors
   - hole saws
   - sabre saw
   - reciprocating saw
   - electric high speed grinder
   - extension cord

2. Select according to task requirements, set up, maintain, and properly store the following pneumatic power tools :
   - air hammer
   - impact driver
   - disk sander
   - blow gun
   - air ratchet
   - butterfly wrench
   - air hose and filter

3. Describe the basic maintenance procedures for air compressors.

LEARNING ACTIVITIES:

1. Participate in class lectures and discussions. (Objectives 1 - 3)
2. Observe demonstrations of the set up, use, maintenance, and storage procedures for each of the following power tools:
   - drill bits
   - drill motors
   - hole saws
   - sabre saw
   - reciprocating saw
   - electric high speed grinder
   - extension cord
   - air hammer
   - impact driver
   - disk sander
   - blow gun

air ratchet
butterfly wrench
air hose and filter
(Objectives 1 - 3)

3. The instructor will show you the shop's air compressor, describe its parts, and explain how it is maintained. If your shop has a plumbed-in air system your instructor will describe its operation and maintenance.
(Objective 3)

EVALUATION/CHECK-OUT:
The instructor will observe your ability to select, use, maintain, and store power tools and accessories as you perform tasks in the shop. Your performance will be recorded on the Performance Checklist.

RESOURCES:

LEARNING MATERIALS:
(none used)

EQUIPMENT:
1. drill bits
2. drill motors
3. hole saws
4. sabre saw
5. reciprocating saw
6. electric high speed grinder
7. extension cord
8. air hammer
9. impact driver
10. disk sander
11. blow gun
12. air ratchet
13. butterfly wrench
14. air hose and filter

AUDIO VISUAL MATERIALS:
(none used)

NAME____________________________ **STUDENT NO.**____________________________

02.02 **PERFORMANCE CHECKLIST**

MODULE : USING POWER TOOLS

COMPETENCY: Select, use, and maintain electric and pneumatic power tools.

1. ☐ Drill bits
2. ☐ Drill motor
3. ☐ Hole saws
4. ☐ Sabre saw
5. ☐ Reciprocating saw
6. ☐ Electric high speed grinder
7. ☐ Extension cord
8. ☐ Air hammer
9. ☐ Impact driver
10. ☐ Disk sander
11. ☐ Blow gun
12. ☐ Air ratchet
13. ☐ Butterfly wrench
14. ☐ Air hoses and filters
15. ☐

COMPETENCY ACHIEVED? ☐ **YES** ☐ **NO**

EXPLANATION:

MODULE 02.03

USING SHOP TOOLS	INSTRUCTOR GUIDE

COMPETENCY:
Identify, use and maintain shop tools.

INSTRUCTIONAL OBJECTIVES:

The student will be able to:

1. Select according task requirements, use, maintain, and properly store the following shop tools:

For pressing:
hydraulic press.
arbor press.

For cleaning and grinding:
bench grinder
solvent tank
bead blaster
sand blaster
pressure washer

For lifting and moving:
chain hoist
floor jack
bottle jack
jack stands
engine crane
motor hoist
hand truck
trailer tongue dolly
rolling engine stand

For general engine work:
back-in and lift-in motor test tanks
floor mounted engine workstand, powerhead adapter, and gearcase adapter

For precision drilling:
drill press and drill press vise.

For general lubrication use:
cartridge type grease gun
pump style and pressure style gearlube dispensers
lubricant waste containers.

LEARNING ACTIVITIES:

MODULE 02.03

1. Participate in class lectures and discussions.
2. Observe demonstrations of the safe and correct use of the following shop tools.
   - hydraulic press.
   - arbor press.
   - bench grinder
   - solvent tank
   - bead blaster
   - sand blaster
   - pressure washer
   - chain hoist
   - floor jack
   - bottle jack
   - jack stands
   - engine crane
   - motor hoist
   - hand truck
   - trailer tongue dolly
   - rolling engine stand
   - back-in and lift-in motor test tanks
   - floor mounted engine workstand, powerhead adapter, and gearcase adapter
   - drill press and drill press vise.
   - cartridge type grease gun
   - pump style and pressure style gear lube dispensers
   - lubricant waste containers.

EVALUATION/CHECK-OUT:
The instructor will observe your ability to select, use, maintain, and store power tools and accessories as you perform tasks in the shop. Your performance will be recorded on the Performance Checklist.

RESOURCES:

LEARNING MATERIALS:
(none used)

EQUIPMENT:
1. hydraulic press.
2. arbor press
3. bench grinder
4. solvent tank
5. bead blaster
6. sand blaster
7. pressure washer
8. chain hoist
9. floor jack
10. bottle jack
11. jack stands

82

12. engine crane
13. motor hoist
14. hand truck
15. trailer tongue dolly
16. rolling engine stand
17. back-in and lift-in motor test tanks
18. floor mounted engine workstand, powerhead adapter, and gearcase adapter
19. drill press and drill press vise.
20. cartridge type grease gun
21. pump style and pressure style gear lube dispensers
22. lubricant waste containers.

AUDIO VISUAL MATERIALS:
(none used)

NAME____________________________ **STUDENT NO.**____________________________

02.03 **PERFORMANCE CHECKLIST** page 1 of 2

MODULE : USING SHOP TOOLS

COMPETENCY: Identify, use, and maintain shop tools.

1. ☐ Hydraulic press
2. ☐ Arbor press
3. ☐ Bench grinder
4. ☐ Solvent tank
5. ☐ Bead blaster
6. ☐ Sand blaster
7. ☐ Pressure washer
8. ☐ Chain hoist
9. ☐ Floor jack
10. ☐ Bottle jack
11. ☐ Jack stands
12. ☐ Engine crane
13. ☐ Motor hoist
14. ☐ Hand truck
15. ☐ Trailer tongue dolly

COMPETENCY ACHIEVED? ☐ **YES** ☐ **NO**

EXPLANATION:

NAME______________________________ **STUDENT NO.**____________________________

02.03 **PERFORMANCE CHECKLIST** page 2 of 2

MODULE : USING SHOP TOOLS

COMPETENCY: Identify, use, and maintain shop tools.

16. ☐ Rolling engine stand
17. ☐ Back-in and lift-in motor test tanks
18. ☐ Floor mount engine stand and adapters
19. ☐ Drill press
20. ☐ Grease gun
21. ☐ Pump and pressure style gear lube dispenser
22. ☐ Lubricant waste containers

☐
☐
☐
☐
☐
☐
☐
☐

COMPETENCY ACHIEVED? ☐ **YES** ☐ **NO**

EXPLANATION:

MODULE 02.04

USING PRECISION MEASURING TOOLS **INSTRUCTOR GUIDE**

COMPETENCY:

Use precision measuring tools to make fine measurements.

INSTRUCTIONAL OBJECTIVES:

The student will be able to:

1. Name the parts of an inside micrometer, an outside micrometer, a dial caliper, and a vernier caliper.
2. Describe the procedures required to maintain and care for precision measuring tools.
3. Measure objects of varying thicknesses using the calipers and outside micrometer.
4. Measure holes of varying diameter using the calipers, an inside micrometer, and the outside micrometer with telescoping gauges.
5. Use feeler gauges and a surface plate to measure warpage and gaps.
6. Use roller blocks, surface plate, and a dial indicator to measure shaft run-out.

LEARNING ACTIVITIES:

1. Participate in class lectures and discussions.
   (Objectives 1 - 6)
2. Read "The Tools and Rules For Precision Measuring".
   (Objectives 1 - 6)
3. Observe demonstrations of the handling and use of precision measuring tools.
   (Objectives 1 - 6)
4. Use the outside micrometer, inside micrometer, calipers, telescoping gauges, and feeler gauges to measure objects found in the shop.
   (Objectives 3 - 6)
5. Use the surface plate to check objects found in the shop for flatness.
   (Objective 5)

EVALUATION/CHECK-OUT:

1. The instructor will give you a set of standard objects to measure with each of the precision measuring tools. Record the object number and dimensions for each object on the Measuring Tools worksheet. Turn in your Measuring Tools worksheet. The instructor will observe your technique as you work.

RESOURCES:

LEARNING MATERIALS:

MODULE 02.04

1. Reference or individual copies of:
   "The Tools & Rules For Precision Measuring",
   Bulletin No. 1211, Issue 3, 11-1-83,
   The L.S. Starrett Co.
   Athol, MA 01331

EQUIPMENT:

1. Outside Micrometer Set 0" to 6".
2. Inside Micrometer or Telescoping Gauges.
3. 6" Dial or Vernier Caliper.
4. 1" Depth Micrometer.
5. Feeler gauges.
6. Dial Indicator w/ base.
7. Surface plate.
8. Roller Blocks.

(For tool specifications see the Tool List in the front of this document.)

AUDIO VISUAL MATERIALS:
(none used)

MODULE 02.04

Precision Measuring Tools Worksheet

NAME________________________________ STUDENT NO.________________

The Outside Micrometer

1.
2.
3.
4.
5.
6.
7.
8.
9.
10.

The Calipers

1.
2.
3.
4.
5.
6.
7.
8.
9.
10.

The Depth Micrometer

1.
2.
3.
4.
5.
6.
7.
8.
9.
10.

MODULE 02.04

The Inside Micrometer or Telescoping Gauges and Outside Micrometer

1.
2.
3.
4.
5.
6.
7.
8.
9.
10.

The Surface Plate and Feeler Gauges

1.
2.
3.
4.
5.
6.
7.
8.
9.
10.

Roller Blocks and The Dial Indicator

1.
2.
3.
4.
5.
6.
7.
8.
9.
10.

NAME________________________ **STUDENT NO.**________________________

02.04 **PERFORMANCE CHECKLIST**

MODULE : Using Precision Measurements

COMPETENCY: Use precision measuring tools to make fine measurements.

1. ☐ Named the parts of outside micrometer and calipers.
2. ☐ Completed Measuring Tools worksheet.
3. ☐ Followed procedure for care and handling of tools.
4. ☐
5. ☐
6. ☐
7. ☐
8. ☐
9. ☐
10. ☐
11. ☐
12. ☐
13. ☐
14. ☐
15. ☐

COMPETENCY ACHIEVED? ☐ **YES** ☐ **NO**

EXPLANATION:

UNIT 3 - HARDWARE

MODULE 03.01

IDENTIFYING MECHANICAL FASTENERS **INSTRUCTOR GUIDE**

COMPETENCY:
Select and use common mechanical fasteners for repairing and maintaining outboard motors and boats.

INSTRUCTIONAL OBJECTIVES:

The student will be able to :

1. Identify the various types of the following common fasteners:
    - wood screws
    - sheet metal screws
    - machine screws
    - bolts
    - studs
    - washers
    - nuts
    - rivets
    - pins
    - retaining rings
    - keys
2. Measure the thread pitch of bolts and machine screws.
3. Explain the meaning of the terms National Coarse and National Fine.
4. Detect the grading marks on bolts and look up their meaning.
5. Recognize screw head types.
6. Identify thread locking compounds and state the typical use for each.
7. Select and apply thread locking compounds according to task requirements.
8. Use a pop-rivet gun to fasten pieces of sheet metal.
9. Select crimp-on wire terminals according to wire size.
10. Use a terminal crimper to attach crimp-on wire ternminals to pieces of wire and to connect two pieces of wire.

LEARNING ACTIVITIES:

1. Participate in class lectures and discussions.
(Objectives 1 - 10)
2. Read the Information Sheet "Mechanical Fasteners".
(Objectives 1 - 8)
3. Observe the following demonstrations:
    - How to apply Thread Locking Compounds.
    (Objectives 6, 7)
    - Installing Pop-Rivets.
    (Objective 8)
    - Using Crimp Terminals.
    (Objectives 9, 10)
4. Use a screw gauge to determine the size of various machine screws found in the shop. Observe the type of head on each

screw. Classify each screw as NF or NC. (Objectives 1 - 3, 5)

5. Use a steel scale and a pitch gauge to determine the size of various bolts found in the shop. Look up the grade of the bolts you are measuring. Classify each bolt as NF or NC. (Objectives 2 - 4)
6. Use a terminal crimper to attach examples of crimp-on wire terminals to scrap wire pieces of assorted sizes.

EVALUATION/CHECK-OUT:

1. The instructor will provide examples of fasteners for you to identify. Your results will be recorded on the Performance Checklist.
2. The instructor will observe your selection and use of thread locking compounds as you work to complete tasks in the shop. Your performance will be recorded on the Performnace Checklist.
3. The instructor will observe your selection and use of crimp-on terminals as you work to complete tasks in the shop. Your performance will be recorded on the Performance Checklist.

RESOURCES:

LEARNING MATERIALS:

1. Information Sheet
"Mechanical Fasteners"
This information sheet adapted from Introduction to Automotive Mechanics--Student Guide, State of Florida Department of Education, Tallahassee, Florida, 1979.

EQUIPMENT:

1. Assortment mechanical fasteners.
2. Screw gauge.
3. Steel rule.
4. Thread pitch gauge.
5. Assortment of crimp-on terminals and a terminal crimper.
6. Samples of wire.
7. Thread locking compound and primer.
8. Pop-rivet gun, pop-rivets, sheet metal samples.

AUDIO VISUAL MATERIALS:

(none used)

NAME ______________________ STUDENT NO. ______________________

03.01

PERFORMANCE CHECKLIST

MODULE : Identify and Using Mechanical Fasteners

COMPETENCY: Select and use mechanical fasteners for repairing outboard motors and boats.

1. ☐ Identified fasteners.
2. ☐ Determined bolt size, thread pitch and grade.
3. ☐ Determined screw size, head type, and thread pitch.
4. ☐ Installed pop-rivets.
5. ☐ Installed wire crimp terminals.
6. ☐ Selected and applied thread locking compounds.
7. ☐
8. ☐
9. ☐
10. ☐
11. ☐
12. ☐
13. ☐
14. ☐
15. ☐

COMPETENCY ACHIEVED? ☐ YES ☐ NO

EXPLANATION:

INFORMATION SHEET

MECHANICAL FASTENERS

MACHINE SCREWS.

The diameters of machine screws are given in numbers such as 4, 6, 8, 10, or 12. The actual diameters of the various sizes are shown in Figure 2-1. Study this diagram very closely.

A thread pitch gauge is used to count the number of threads per inch on a machine screw. The number on the gauge tells you the number of threads per inch that are on a screw. Figure 2-2 shows how a screw is measured with a thread pitch gauge.

Threads on machine screws are identified as two basic types: NF and NC. NF means National Fine and NC means National Coarse. NF threads always have more threads per inch then NC. Sometimes threads are classified as NEF, which stands for National Extra Fine. There are more threads per inch in NEF screws than either NF or NC threads (see Figure 2-3).

Figure 2-1 Characteristics of machine screws

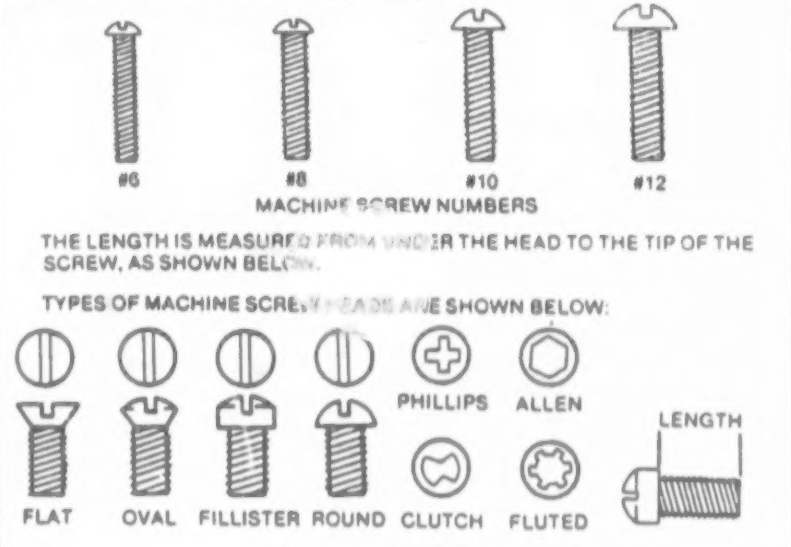
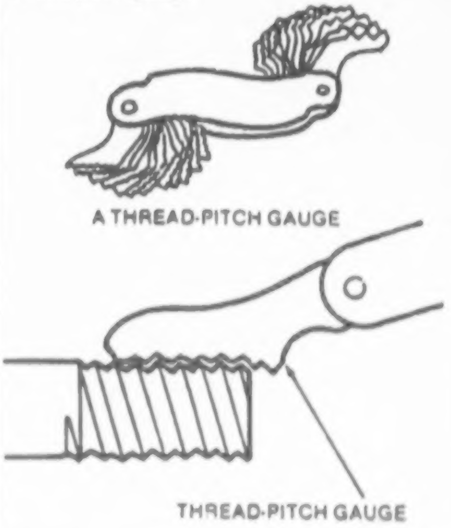

#6
#8
#10
#12
MACHINE SCREW NUMBERS
THE LENGTH IS MEASURED FROM UNDER THE HEAD TO THE TIP OF THE SCREW, AS SHOWN BELOW.
TYPES OF MACHINE SCREW HEADS ARE SHOWN BELOW:
PHILLIPS
ALLEN
LENGTH
FLAT
OVAL
FILLISTER
ROUND
CLUTCH
FLUTED

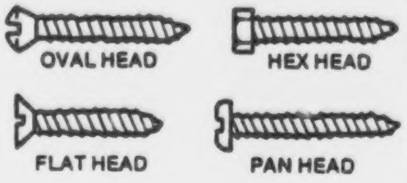
Figure 2-2 Measuring a screw with a thread pitch gauge


A THREAD-PITCH GAUGE
THREAD-PITCH GAUGE

SHEET METAL SCREWS

Sheet metal screws are available in different lengths and diameters. Also, sheet metal screws have different kinds of heads (see Figure 2-4). These screws are used to fasten thin sheet metal together and to attach various items to sheet metal. They need no threads because they make their own.

Figure 2-4 Types of sheet metal screws

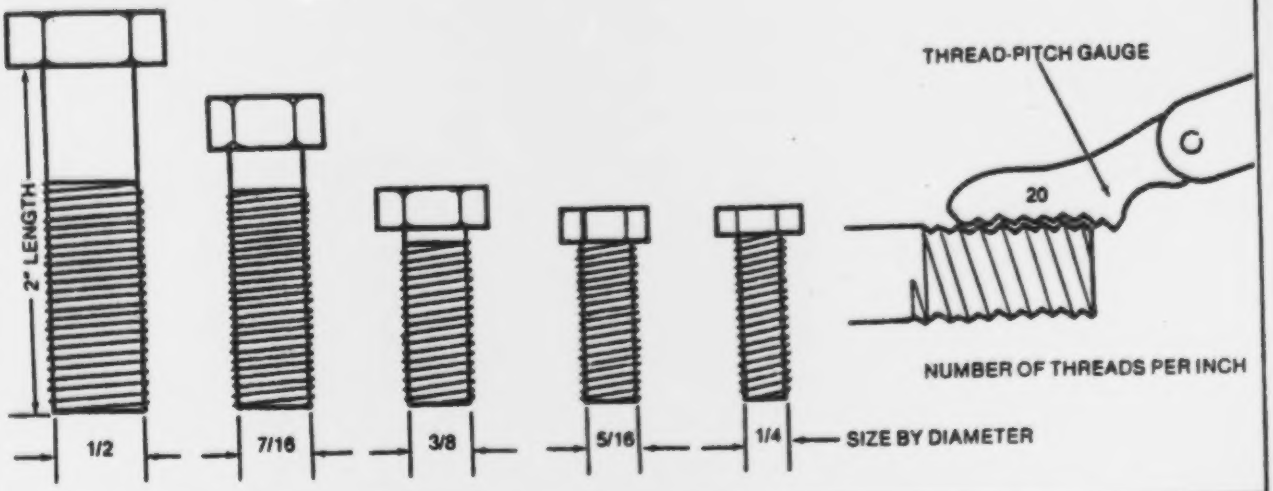


BOLTS

Most bolts used in automotive work are hex-head bolts. They are measured by the diameter of the shaft, the length of the shaft, and the number of threads per inch. Bolts start at 1/4-inch diameter. A bolt this size is slightly larger than a number 12 machine screw. Bolt diameters increase in size in 1/16-inch increases (see Figure 2-5). The threads of bolts are measured just like those of machine screws.

EXAMPLE: A 5/16 x 18 x 2 1/2-inch hex-head bolt is a bolt which is 5/16 inch in diameter, has 18 threads per inch, and is 2 1/2 inches long.

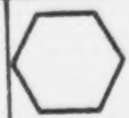
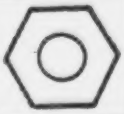
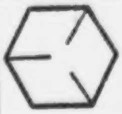
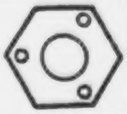
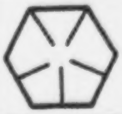
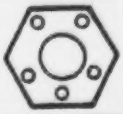
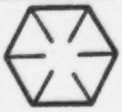
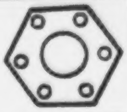
Figure 2-5 Bolt size characteristics


2" LENGTH
1/2
7/16
3/8
5/16
1/4
SIZE BY DIAMETER
THREAD-PITCH GAUGE
20
NUMBER OF THREADS PER INCH

GRADING BOLTS

All bolts are not made of the same quality of material. The strength of a bolt is referred to as its tensile strength. You can tell what the tensile strength of a bolt is by looking at its head, as shown in Figure 2-6. As you can see, if the bolt has three marks on the head, it is Grade 5. This means that its tensile strength (resistance to breakage) is 120,000 psi (pounds per square inch). It is a standard strength bolt.

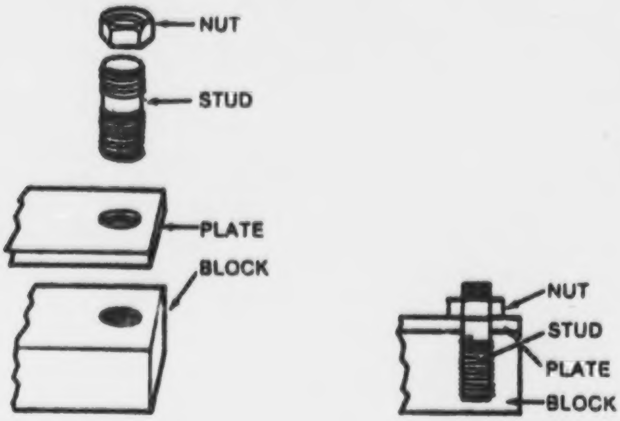
Figure 2-6 Bolt grades

S.A.E. GRADE	MARKINGS S.A.E.	METRIC	TENSILE STRENGTH IN P.S.I.	
1 or 2			60,000	STANDARD STRENGTH
5			120,000	
7			133,000	
8			150,000	HIGH STRENGTH

STUDS

A stud has no head and has fine threads on one end and coarse threads on the other end. In Figure 2-7, the stud is secured through a tight fitting hole, and a nut anchors the plate to the block.

Figure 2-7 Before and after fastening the stud



BEFORE FASTENING

AFTER FASTENING

METRIC SCREWS, BOLTS, NUTS, AND WASHERS

Metric fastener specifications are controlled by two international organizations. DIN (Deutsche Industry Normen) has a very complete set of standards. Many countries recognize and use this system. ISO (International Standards Organization) coordinates metric fastener standards so that they will be interchangeable throughout the world. You will notice that metric nut, bolt, and screw sizes are preceded by DIN or ISO.

MACHINE SCREWS-METRIC. Metric machine screws are classifed by diameter and length in millimeters. The diameters commonly used in marine applications will be from 3 millimeters to about 6 millimeters. The length will be from about 10 millimeters to 50 millimeters.

EXAMPLE: Pan DIN M4 x 20 means a pan head machine screw with Deutsche Industry Normen standards. This screw is 4 millimeters in diameter and 20 millimeters in length.

HEX HEAD BOLTS-METRIC. Metric bolts are also classified by diameter and length in millimeters. The bolt diameter starts where the machine screw diameter leaves off. The most common diameters of metric bolts used in marine applications will be from about 6 to 16 millimeters. Lengths will be from 10 to 100 millimeters.

METRIC THREADS

The threads on metric machine screws and bolts are measured differently from the English system of measurement. Instead of measuring the number of threads per inch (English), you meausre the distance from one thread to the next in millimeters. This measurement is called the thread pitch.

Metric thread pitch for the smallest size is 0.35 millimeter. The largest size is 6 millimeters.

NUTS

Many of the nuts used in marine applications are illustrated and described below.

Nuts are identified by inside diameter. For example, a number 6 machine screw uses a number 6 machine screw nut or a 5/16 NF bolt requires a 5/16 NF nut.

The nut that you will use most frequently is the standard hex nut, shown in Figure 2-8.

You will also use some special nuts. Study the following types of special nuts closely.

Locknut This nut, sometimes called a nylock nut, is a standard hex nut with a nylon locking ring built onto it (see Figure 2-9). This ring creates friction between the threads of the bolt and nut. As a result, the ring locks the nut in place.

Figure 2-8 Hex nut

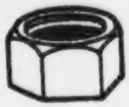
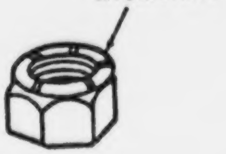


Figure 2-9 Locknut



Jam nut. The jam nut is a nut that isused to lock against another nut (see Figure 2-10). You will use a jam nut when a nut needs to be locked so that it will not loosen.

Washered nut. This is a standard hex nut with a shakeproof washer attached (see Figure 2-11). You will use this locking nut mostly when working on the body of a vehicle.

Speed nut. You will use this nut mostly with sheet metal screws (see Figure 2-12).

Pal nut. This nut is used to lock another nut (see Figure 2-13). It is tightened finger-tight, plus 1/16 of a turn.

Self-locking split nut. On this nut, the upper section is slotted and the segments are forced together. When the bolt passes through the nut, it spreads the segments apart, causing the nut to lock (see Figure 2-14).

Acorn nut. This nut is used for decorative purposes (see Figure 2-15).

Wing nut. This nut can be removed quickly. It is used on the carburetor air cleaner assembly becuase it must be removed often (see Figure 2-16).

Castle nut. This nut is locked with a cotter pin (see Figure 2-17).

Figure 2-10 Jam nut

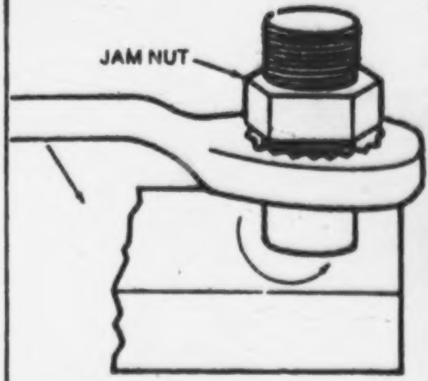


Figure 2-11 Washered nut

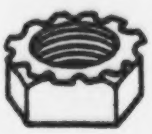


Figure 2-12 Speed nut

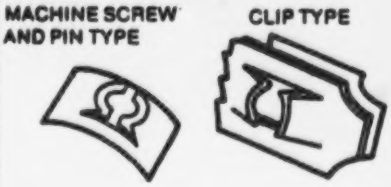


Figure 2-13 Pal nut

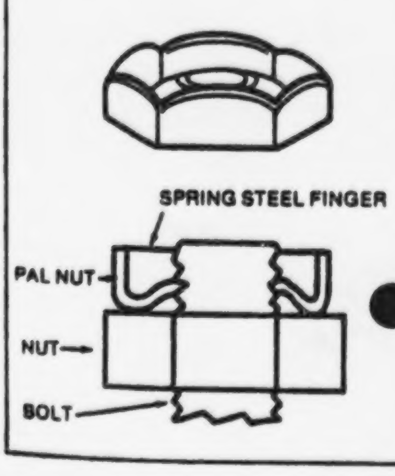


Figure 2-14 Self-locking split nut

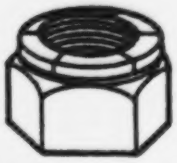


Figure 2-15 Acorn nut

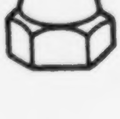


Figure 2-16 Wing nut

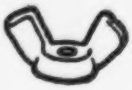
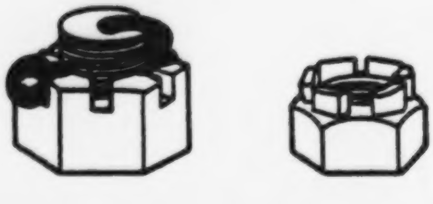


Figure 2-17 Castle nut

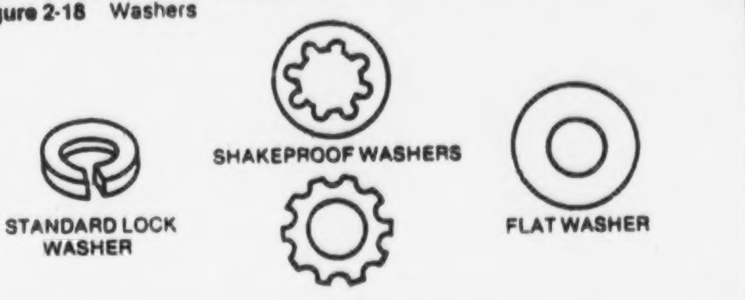


WASHERS

There are two kinds of washers: Locking and flat (see Figue 2-18). The standard lock washer is used to lock a nut in place and prevent it from coming loose. The shakeproof lock washer is used where there is extreme vibration.

The flat washer is used to fill space between the nut and the surface of the object. This washer will not dig into the surface as a lock washer does. Figure 2-18 shows lock and flat washers.

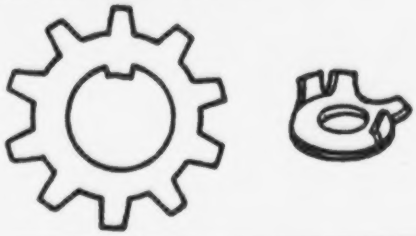
Figure 2-18 Washers



OTHER LOCKING DEVICES

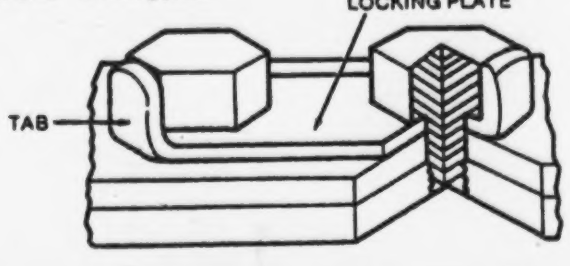
Locking tabs are made of thin metal (see Figure 2-19). After the bolt passes through the locking plate and is tightened, the tabs are bent upward to lock the bolt or nut in place.

Figure 2-19 Before and after bending tabs



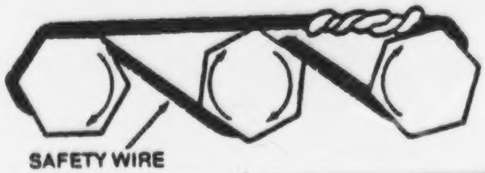
Locking plates are made of thin metal, and are used to lock two bolts together (see Figure 2-20).

Figure 2-20 Locking plate



Locking safety wires are used with bolts that have the heads drilled through so that wire can pass through the head of the bolt. Always pass wire through the bolt in such a manner as to make a clockwise pull (see Figure 2-21).

Figure 2-21 Locking safety wire


SAFETY WIRE

A cotter pin is a split pin made of soft metal so that it can be bent (see Figure 2-22).

A clevis pin is a steel pin used to hold linkage (see Figure 2-23). A clevis pin is held in place with a cotter pin.

A set screw is a locking device used to lock a gear or a collar to a shaft as shown in Figure 2-24. It has either a pointed or cupped end. The set screw keeps the shaft from moving by going into the slot on the shaft.

Figure 2-22 Cotter pin

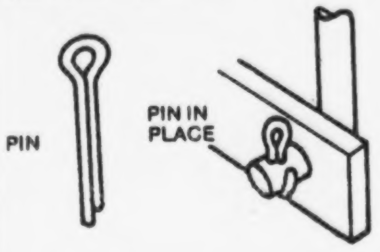

PIN
PIN IN PLACE

Figure 2-23 Clevis pin

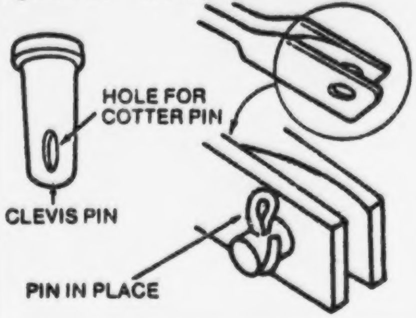
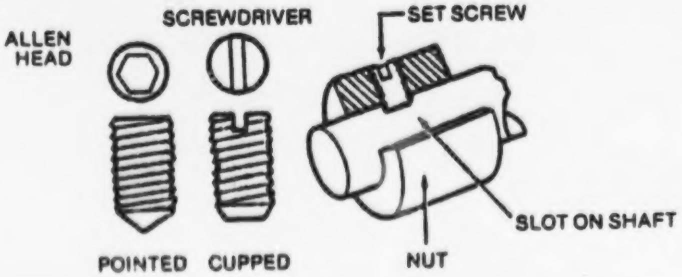

HOLE FOR COTTER PIN
CLEVIS PIN
PIN IN PLACE

Figure 2-24 Set screws


ALLEN HEAD
SCREWDRIVER
SET SCREW
SLOT ON SHAFT
POINTED
CUPPED
NUT

RIVETS

Rivets, shown in Figure 2-25, are used to fasten metal together.

Rivets may have a solid shank or a hollow shank. Figure 2-26 shows how to use a rivet set tool to install a solid-shank rivet.

Figure 2-27 shows how to use a rivet set tool to install a hollow-shank rivet.

Figure 2-25 Rivets

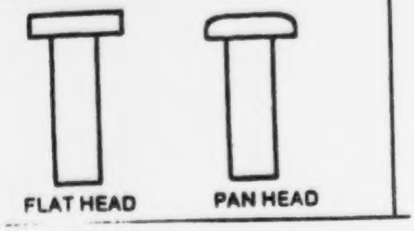

FLAT HEAD
PAN HEAD

Figure 2-26 Installing a solid-shank rivet

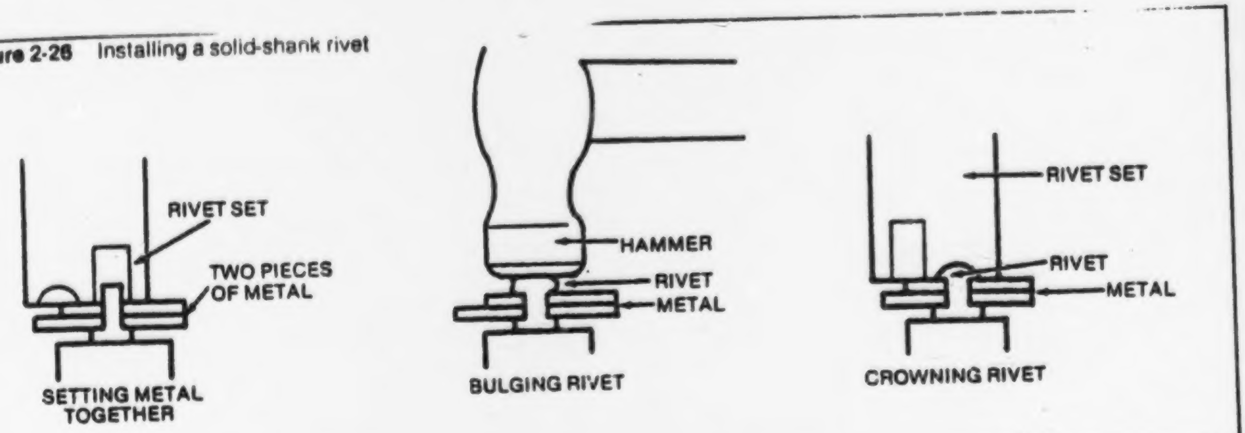
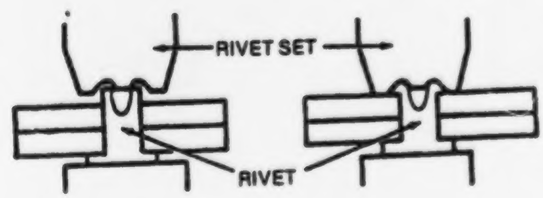

RIVET SET
TWO PIECES OF METAL
SETTING METAL TOGETHER
HAMMER
RIVET
METAL
BULGING RIVET
RIVET SET
RIVET
METAL
CROWNING RIVET

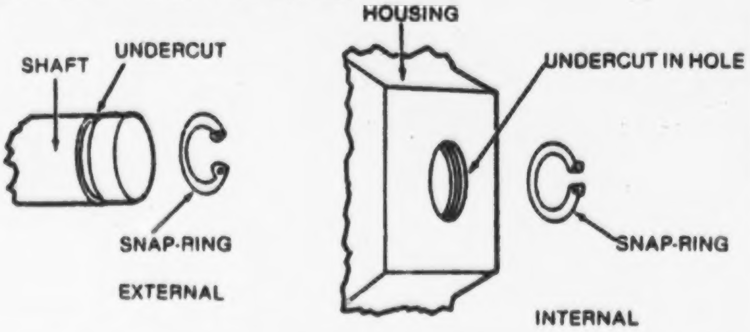
Figure 2-27 Installing a hollow-shank rivet


RIVET SET
RIVET

SNAP-RINGS

Snap-rings are used to stop the endwise movement of a gear or collar on a shaft. There are two basic types of snap-rings: external and internal (see Figure 2-28). These standard type snap-rings use special pliers for removal and replacement.

Figure 2-28 Two types of snap-rings


HOUSING
SHAFT
UNDERCUT
UNDERCUT IN HOLE
SNAP-RING
EXTERNAL
SNAP-RING
INTERNAL

KEYS, SPLINES, AND PINS

Keys, splines, and pins are used to secure a gear pulley or a collar to a shaft. These locking devices are not bent. They fit together to lock.

Figure 2-30 shows a woodruff key holding a gear to a shaft. Straight keys can also be used to do this.

Splines are used when the shaft should not rotate but be free to slide backward and forward (see Figure 2-31).

Straight, tapered, or split pins are also used as locking devices. For example, these pins may be used to lock a gear or pulley to a shaft (see Figure 2-32).

Figure 2-30 Woodruff key and straight key

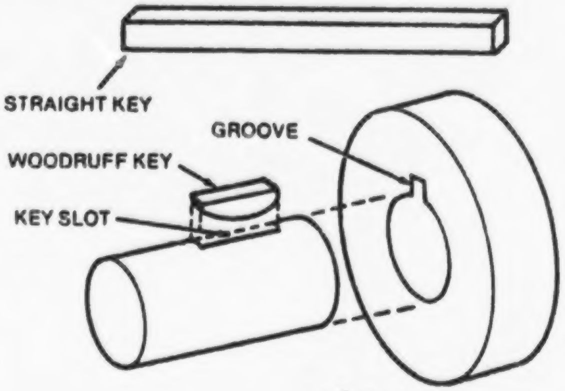

STRAIGHT KEY
GROOVE
WOODRUFF KEY
KEY SLOT

Figure 2-31 Spline

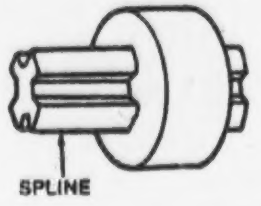


Figure 2-32 Pins

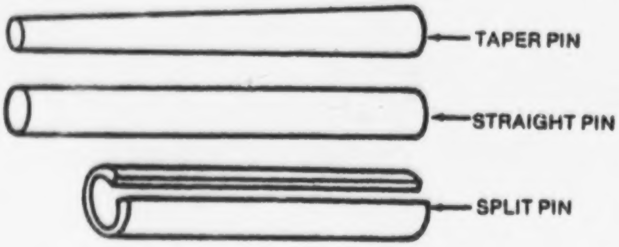

TAPER PIN
STRAIGHT PIN
SPLIT PIN

Figure 2-3 Machine screw and bolt sizes (fine and coarse)

			Threads Per Inch					
	Size	Diameter (decimal)	Coarse (UNC or NC)	Fine (UNF or NF)	Extra-Fine (UNEF or NEF)	8-Thread Series	12-Thread Series	16-Thread Series
Machine Screw Sizes	0	0.0600	...	80				
	1	0.0730	64	72				
	2	0.0860	56	64				
	3	0.0990	48	56				
	4	0.1120	40	48				
	5	0.1250	40	44				
	6	0.1380	32	40				
	8	0.1640	32	36				
	10	0.1900	24	32				
	12	0.2160	24	28	32			
Bolt Sizes	1/4	0.2500	20	28	32			
	5/16	0.3125	18	24	32			
	3/8	0.3750	16	24	32			
	7/16	0.4375	14	20	28			
	1/2	0.5000	13	20	28		12	
	9/16	0.5625	12	18	24		12	
	5/8	0.6250	11	18	24		12	
	3/4	0.7500	10	16	20	...	12	16
	7/8	0.8750	9	14	20	...	12	16
	1	1.0000	8	12	20	8	12	16
	1 1/8	1.1250	7	12	18	8	12	16
	1 1/4	1.2500	7	12	18	8	12	16
	1 3/8	1.3750	6	12	18	8	12	16
	1 1/2	1.5000	6	12	18	8	12	16

EXAMPLE 1: An 8 x 32 x 1 1/2-inch screw is a number 8 size screw with 32 threads per inch, and is 1 1/1 inches long. Look at the chart and you will find that an 8 x 32 x 1 1/2-inch screw is a coarse thread.

EXAMPLE 2: A 10 x 32 x 1 1/2-inch screw is a number 10 diameter screw with 32 threads per inch, and is 1 1/2 inches long. Look at the chart in Figure 2-3. You see that a 10 x 32 x 1 1/2-inch screw is a fine thread.

MODULE 03.02

FREEING SEIZED HARDWARE **INSTRUCTOR GUIDE**

COMPETENCY:
Remove fasteners which have become seized and repair damaged threads as necessary.

INSTRUCTIONAL OBJECTIVES:
The Student will be able to:
1. Identify the two major causes of frozen or stuck threaded fasteners.
2. Identify common chemical agents for preventing corrosion on threaded fasteners.
3. Set up the oxy-acetylene torch for heating.
4. Use the oxy-acetylene torch to heat and remove fasteners which are stuck in aluminum castings.
5. Use the "back and forth" method to remove seized fasteners.
6. Select and use penetrating oils.
7. Identify the parts in a tap an die set.
8. Repair damaged threads in aluminum castings with thread chasers.
9. Repair the threads on machine screws and bolts using thread files and/or threading dies.
10. Remove stainless steel fasteners which have been broken off in aluminum castings by drilling them out.
11. Repair damaged threads in aluminum castings by installing Heli-coils.
12. Repair damaged threads in aluminum castings by using Loctite Form-a-Thread.

LEARNING ACTIVITIES:
1. Participate in class lectures and discussions.
(Objectives 1 - 12)
2. Read the Information Sheet "Setting Up the Oxy-Acetylene Torch For Heating." Observe a demonstration on how to set up the oxy-acetylene torch for heating then practice setting up the torch yourself.
(Objective 3)
3. Go to the tool room and familiarize yourself with the tap and die set and/or the thread chaser set and the thread files. Observe demonstrations on the set up and use of tap, dies, thread chasers, and thread files.
(Objectives 7 - 9)
4. Read the Information Sheet "Removing Seized Fasteners". Observe a demonstration of the techniques for removing stuck fasteners using heat and the "back and forth" method.
(Objectives 4, 5)
5. Read the Information Sheet "Restoring Destroyed Threads In

Aluminum Castings". Observe demonstrations of thread restoration using Heli-Coils and Loctite Form-a-Thread. (Objectives 11, 12)

6. Practice the techniques you have learned as you encounter seized fasteners and damaged threads in the shop.

EVALUATION/CHECK-OUT:
The instructor will observe your ability to select and set up tools, remove seized fasteners, and repair damaged threads in the shop as you work on projects. Your performance will be recorded on the Performance Checklist.

RESOURCES:

LEARNING MATERIALS:

1. Information Sheet
   "Setting Up the Oxy-Acetylene Torch For Heating"
   (Master copy included in this guide.)

2. Information Sheet
   "Removing Seized Fasteners"
   (Master copy included in this guide.)

3. Information Sheet
   "Restoring Destroyed Threads In Aluminum Castings"
   (Master copy included in this guide.)

EQUIPMENT:

1. Examples of anti-corrosion agents used on fasteners, e.g., Gasket Sealing Compound, Never-Seize, anti-corrosion grease.
2. Oxy-acetylene torch kit with various welding tips and heating tips.
3. Tap and die set.
4. Thread chasers.
5. Thread files.
6. Examples of penetrating oils.
7. Heli-Coil kits in various common sizes.
8. Loctite Form-a-Thread.
9. Basic hand tools.

AUDIO VISUAL MATERIALS:
(none used)

SIEZED HARDWARE INFORMATION SHEET

SETTING UP THE OXY-ACETYLENE TORCH FOR HEATING

SAFETY PRECAUTIONS

DO NOT ATTEMPT TO USE THE OXY-ACETYLENE TORCH KIT UNLESS YOU HAVE BEEN CHECKED OUT BY THE INSTRUCTOR.

ALWAYS wear safety glasses when using the oxy-acetylene torch for heating.

Keep a fire extinguisher close at hand while operating the torch.

NEVER attempt to use a torch kit that appears to be damaged. DO NOT ATTEMPT TO REPAIR THE TORCH KIT. Notify the instructor of damaged equipment immediately.

Do not attempt to light the torch with anything except an approved striker.

Make sure that the parts to be heated are securely held in place with some type of clamp.

Always remove combustible materials which are near or on the parts which will be heated. Remove grease and oil from parts to be heated.

Keep all petroleum products away from the torch kit. Oil can react with oxygen at normal room temperatures and cause an explosion.

Make arrangements to have equipment on hand to handle very hot parts if you are using heat to aid in a disassembly procedure.

If you intend to leave hot parts unattended make sure that they are clearly labelled as HOT. Use soapstone to mark the parts or a sign if necessary.

NEVER operate the torch kit when the cylinders are not in a VERTICAL position.

NEVER go on break or to lunch or leave the torch kit unattended without shutting it down.

MODULE 03.02

PREPARING THE TORCH FOR LIGHTING

Choose a torch tip according to the heating job. Generally, for large heating jobs you select large tips.

Before attaching the tip to the torch barrel make sure that the O-rings for sealing the tip to the barrel are in place and undamaged.

Attach the tip to the torch barrel using hand pressure only. DO NOT USE TOOLS.

Before opening the oxygen and acetylene cylinder valves make sure that the regulators are not open. The regulators have diaphragms in them which can be damaged if the cylinder valves are opened with the regulators on.

Slowly open the oxygen cylinder valve until the oxygen pressure gauge reaches its maximum reading then open it the rest of the way.
Open the acetylene cylinder valve ONE TURN ONLY. This provides for a quick turn off in an emergency.

Open the regulator valves by turning the adjusting screw in on each valve until the desired pressure reading on the gauge is obtained. For general heating purposes use about 5psi oxygen and 5psi acetylene.

For a count of 5 open and close both the torch valves, (one at time), to blow out any air or dust that might have gotten the hoses or torch.

To light the torch open the acetylene valve on the torch barrel about 1/8 of a turn and use a proper striker to strike a flame at the torch tip. Adjust the acetylene valve until the flame begins to blow away from the torch tip then close it until the flame just comes back. Open and adjust the oxygen valve until a just-off-feather neutral flame is produced.

SHUTTING THE TORCH OFF

Close the torch oxygen valve.

Close the torch acetylene valve.

SHUTTING THE TORCH KIT DOWN

Close the acetylene tank valve.

Bleed the pressure off the acetylene regulator by opening the acetylene valve on the torch barrel.

Close the oxygen tank valve.

Bleed the pressure off the oxtgen regulator by opening the oxygen valve on the torch barrel.

Close the valves on the torch barrel completely.

Shut off the regulators by turning their adjusting screws out until they turn freely.

Remove the tip from the torch barrel and clean it. Store it in its container.

Coil the hoses onto the welding cart taking care to store the torch barrel properly.

Wheel the welding cart to its storage place.

MODULE 03.02

SEIZED HARDWARE INFORMATION SHEET

REMOVING SEIZED FASTENERS

In Marine Mechanics there are two general causes for fasteners becoming seized in the parts that they were designed to attach: corrosion and mechanical damage. Marine engines and boats are found around water and water helps to cause corrosion. Corrosion is by far the leading cause of stuck fasteners on boats and marine engines. Mechanical damage to fasteners is usually in the form of breakage or shearing and does not occur frequently.

Removing seized fasteners quickly and with little or no damage to the attached parts is a skill which usually relies on a combination of techniques and can be learned with a little practice. The techniques are:

1. Applying penetrating oils;
2. Using screw extractors;
3. Using "Back and Forth" method;
4. Applying heat.
5. Drilling out.

Applying Penetrating Oils

The use of penetrating oils such as Liquid Wrench or WD40 is generally limited to stuck fasteners which are made of iron or steel. It is usually used to help free fasteners which are rusted together. The penetrant is applied to the stuck parts and allowed to sit overnight or some other long period of time. Since rust is a porous type of corrosion the oil can seep down around the threads to help lubricate the fastener to ease its extraction. This method generally does not work to help free stainless fasteners from aluminum castings because the corrosion is not a porous type and the oil will not seep down. Penetrating oils are generally used with one or more of the other methods to help free the fasteners.

For certain situations such stuck as plastic or aluminum parts where corrosion is not a factor penetrants can be tried.

Using Screw Extractors

Screw extractors are usually used to remove a screw or bolt which has had its head broken off by some type of shear force and the threads are all in good shape. A hole of the size specified on the extractor is drilled in the fastener shank and the extractor is either screwed or pounded into the hole. The extractor is then turned to unscrew the fastener.

Screw extractors do not work when corrosion or heavy damage is involved. The force necessary to work the corroded or damaged fastener back and forth is usually greater than the extractor's ability to hold on to it. If it looks clean you can try a screw extractor.

The "Back and Forth" Method

The "Back and Forth" method is used when the stuck fastener is not completely frozen. If the fastener can be turned a small amount without great force it can probably be worked loose by continually turning it back and forth. This method does not work on every fastener that can be turned a small amount and if used improperly will almost always result in shearing the head off the fastener. It is important to develop a feel for which fasteners can be removed with the "Back and Forth" method and that feel comes with practice.

Generally, the "Back and Forth" method can be used in combination with all of the other techniques when there is still at least a piece of the stuck fastener to hold on to. Penetrating oils and heat are used to get the fastener to turn back and forth more easily.

The Heat Method

The heat method is the most effective means of freeing seized fasteners. It is almost always used in combination with the "Back and Forth" method. Heat works in two ways to help free the fastener. Heat causes the metal casting which is holding the fastener to expand and let go of it. Heat also causes the corrosion around the fastener to soften allowing it to be broken up as the fastener is turned.

The most common source of heat used to free seized fasteners is the oxy-acetylene torch. It is used because of its ability to deliver large amount of heat quickly. It is necessary to raise the temperature of the casting in which the fastener is stuck without also heating the fastener. This might seem like an impossible task but when the direct flame is kept away from the fastener and on the casting the casting will absorb most of the heat first. The fastener will get hot but it is the temperature differential between the fastener and the casting which is important. The casting must expand more than the fastener.

When heating aluminum castings with the oxy-acetylene torch extreme care must be used. Aluminum melts quickly at a much lower temperature than steel and will do so without warning. Aluminum will not glow before it becomes liquid. Aluminum does not get soft before it becomes a liquid. Expensive aluminum castings can be ruined in an instant when carelessness is at hand. The secret to success is to keep the torch flame moving and to continually test the fastener with the "Back and Forth" method while the casting is being heated. The fastener will always come loose or break before the casting melts. You will find that once the fastener is able to be turned you usually do not need more heat. Shut off the torch and concentrate on turning out the fastener. You will develop a feel for how much heat is required as you gain experience. You must also remember that it is easier to twist the head off a hot bolt or screw than a cold one.

Once you have removed the fastener be sure to mark all parts left to cool as HOT. Use a piece of soapstone or make a sign to put on the parts. If you need to cool the parts down to work on them immediately run water over them to remove the heat. You can blow the excess water off with compressed air.

Always inspect the threads in the casting after using heat to remove a fastener. Remove the corrosion using a thread chaser or a tap then blow it out with compressed air. On critical assemblies such as exhaust manifolds, gearcase to exhaust tower screws, or starter motor mounts, or any other assembly where stress or corrosion will be a factor the best practice is to repair corroded/damaged casting threads with a thread insert such as a Heli-Coil.

The Drill Out Method

When all other methods of removing a stuck fastener have failed or you have twisted the head off the fastener and there is nothing left to grab on to you must drill the fastener shank out of the casting and then repair the casting threads. If the part is small and has flat surfaces it can be taken to the drill press. Often the part will be too large or will have an odd shape which will prevent the use of the drill press. Therefore the hand held drill motor is the tool of choice for drilling out fastener shanks.

Most of the fasteners which you will attempt to drill out will be stainless steel and they will be in aluminum castings. The aluminum casting is much softer than the stainless fastener so great care must be taken not to let your drill bit drift off the fastener shank. If you take too much aluminum as you are drilling or gouge out a big hole by mistake there is a chance that the threads may not be able to be repaired. If the hole cannot be filled by a welder using aluminum rod and then later be retapped the casting is ruined. As you are learning this procedure you must substitute great care and time for experience to help you avoid mistakes. Make sure to use high quality, sharp drill bits and then check and recheck the progress of you hole frequently.

Summary

You will find that in most situations a combination of some or all of the methods for freeing seized fasteners will be required. Always remember that you are trying to save the assembly that the fastener is stuck in and not the fastener. Nuts, bolts, and screws are cheap and should be sacrificed as necessary to save the more expensive parts. Additionally, you must learn when seized hardware techniques should not be used. There is no sense in attempting to save a forty dollar part with eighty dollars worth of labor. In class the instructor can help you learn when to use seized hardware techniques. When you are on the job your service manager will help you to decide whether to repair or replace parts with stuck fasteners.

MODULE 03.02

SEIZED HARDWARE INFORMATION SHEET

RESTORING DESTROYED THREADS IN ALUMINUM CASTINGS

Whenever bolt hole or screw hole threads in aluminum castings have been stripped out due to cross-threading, overtorquing, overuse, or corrosion and will not safely accept the original size fastener a Heli-Coil thread insert may be used to restore the threads.

Heli-Coil thread inserts are precision formed from stainless steel wire which is cold rolled to have a diamond shaped cross-section and then wound into a spiral coil. A special removable tang is bent into the end of the wire forming the bottom loop of the Heli-Coil. This tang is used prevent the Heli-Coil from turning on the insertion tool during installation. When the Heli-Coil is installed into a special Heli-Coil tapped hole it provides conventional 60 degree screw threads.

Before they are installed Heli-Coil inserts are slightly larger in diameter than the tapped hole they will go into. During installation the insertion tool applies torque to the tang reducing the diameter of the first loop on the Heli-Coil permitting it to enter the hole. After the Heli-Coil has been wound into the hole the spring action of the coils pushes outward on the casting and anchors the insert.

There are two designs of Heli-Coil inserts: Standard, which provides a smooth free running thread; and, Screw-Lock which provide a thread locking ability due to a specially bent coil in the insert.

To install a Heli-Coil insert follow the following procedure:

1. Locate the appropriate Heli-Coil kit for your original fastener. The kit will contain Heli-Coils, the special Heli-Coil tap for that kit, and an insertion tool.

2. Locate your drill motor and the size of drill bit specified in the Heli-Coil kit.

3. Drill out the old damaged thread in the casting taking great care to follow the exact line of the old fastener. This is usually at right angles to the work, but not always. Do not go deeper than the original hole. You do not want to drill through a piece which must hold pressure or water. Blow the metal bits out of the hole with compressed air.

4. Place the special Heli-Coil tap into an appropriate tap handle and tap

the hole you just drilled. Again, take great care to follow the line of the original fastener. Clear the tapped hole of metal bits with compressed air.

5. Put the Heli-Coil insertion tool into an appropriate tap handle and thread a Heli-Coil onto the end of it. The insertion tool should engage the removable tang on the end of the Heli-Coil.
   Screw the Heli-Coil into the tapped hole until its top loop is flush or slightly below the surface if the work. Remove the insertion tool by turning it out of the Heli-Coil and hole.

6. Locate a pin punch with a diameter slightly smaller than the inside diameter of the installed Heli-Coil. Use the pin punch to break off the tang at the end of the Heli-Coil down inside the hole. Remove the broken off tang by blowing it out with compressed air. Take care not to bend the tang down instead of breaking it. A tang which is bent down is difficult if not impossible to remove and almost always results in the need to remove the Heli-Coil.

NAME________________________ **STUDENT NO.**______________________

03.02

PERFORMANCE CHECKLIST

MODULE : Freeing Seized Harware

COMPETENCY: Remove seized fasteners and repair damaged threads

1. ☐ Set up oxy-acetylene torch for heating
2. ☐ Followed rules for safety while using torch
3. ☐ Shut down oxy-acetylene torch
4. ☐ Removed fasteners using "back and forth" method
5. ☐ Selected and used penetrating oils
6. ☐ Removed fasteners using the heat method
7. ☐ Removed screws with screw removers
8. ☐ Repaired threads with taps/dies, chasers, thread files
9. ☐ Repaired threads using Form-a-Thread
10. ☐ Drilled out broken off screws
11. ☐ Restored threads by installing Heli-Coils
12. ☐
13. ☐
14. ☐
15. ☐

COMPETENCY ACHIEVED? ☐ **YES** ☐ **NO**

EXPLANATION:

UNIT 4 - SERVICE DOCUMENTATION

MODULE 04.01

IDENTIFYING OUTBOARD MODEL/YEAR INSTRUCTOR GUIDE

COMPETENCY:
Determine the model/year of Mercury Marine and OMC outboard motors.

INSTRUCTIONAL OBJECTIVES:

The student will be able to:
1. Locate and interpret serial number information on Mercury Marine outboard motors.
2. Locate and interpret model number information on OMC outboard motors.

LEARNING ACTIVITIES:
1. Participate in class lectures and discussions.
   (Objectives 1 and 2)
2. Read and study the information sheet "Determining the Model Year of Outboard Motors".
   (Objectives 1 and 2)
3. Complete the Model Year worksheet.
   (Objectives 1 and 2)

EVALUATION/CHECK-OUT:
1. Turn in your Model Year worksheet.
2. For each of the engines you will work on in the shop you will be required to locate service literature and specify parts. For each of these tasks you will need to know how to determine the model year of an engine. The instructor will observe your ability to determine year models and will record your performance on the Identifying Outboard Model/Year performance checklist.

RESOURCES:

LEARNING MATERIALS:
1. Information Sheet
   "Determining the Model Year of Outboard Motors"
   (Master copy included in this guide)
2. Model Year worksheet
   (Master copy included in this guide)

EQUIPMENT:
(none used)

AUDIO VISUAL MATERIALS:
(none used)

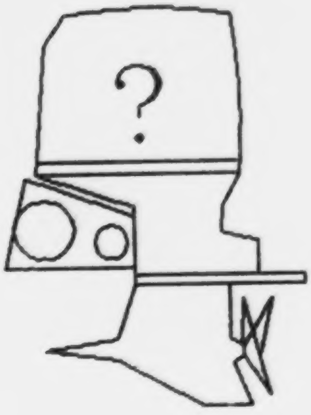
MODULE 04.01

IDENTIFYING OUTBOARD MODEL/YEAR INFORMATION SHEET

Determining the Model Year of Outboard Motors

In order to locate the correct parts and service manuals for a motor that you need to work on it is necessary to know how to read and interpret the information found on engine identification plates. This information sheet will help you learn to read and interpret Mercury Marine and OMC engine identification plates in order to locate service and parts documentation.

Do you recognize this engine?



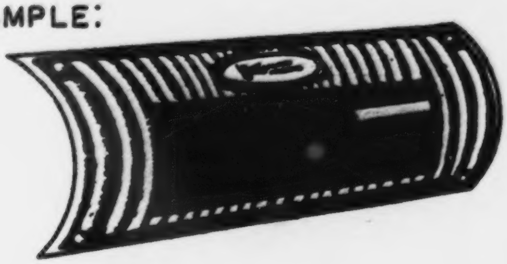
MODULE 04.01

Mercury Marine Engine Identification Plates

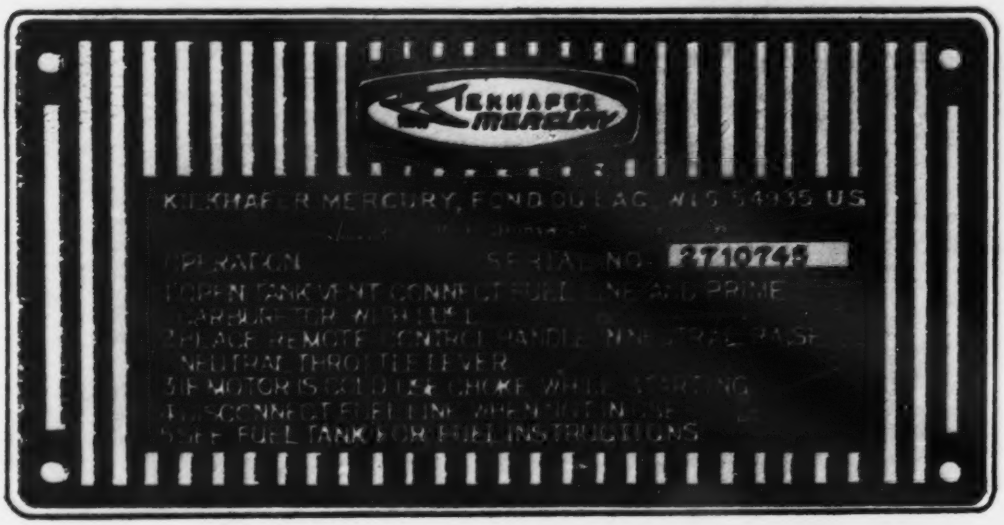
In order to locate the proper parts and service manuals for a particular engine you must first locate the engine identification plate. The following drawings are examples of Mercury Marine engine identification plates showing where on the engine they may be found.

Many Mercury engines have identification plate like the one shown below. In order to fit it on the engine it is formed into a half circle and then fitted to the part of the swivel bracket that attaches to the tilt tube on the stern bracket.

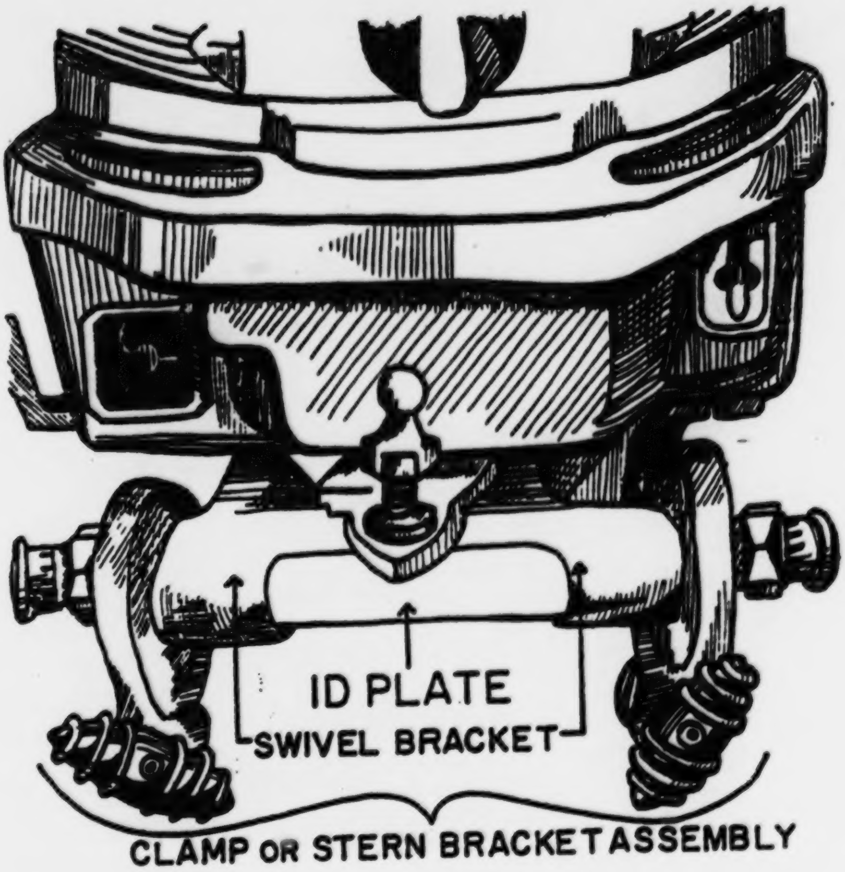
EXAMPLE:

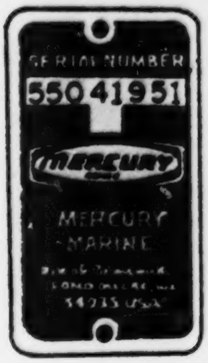


ACTUAL SIZE
FLATTENED OUT:


KIEKHAEFER MERCURY
KIEKHAEFER MERCURY, FOND DU LAC, WIS 54935 US
OPERATION
SERIAL NO. 2710748
1 OPEN TANK VENT CONNECT FUEL LINE AND PRIME CARBURETOR WITH FUEL
2 PLACE REMOTE CONTROL HANDLE IN NEUTRAL NEUTRAL THROTTLE LEVER
3 IF MOTOR IS COLD USE CHOKE WHILE STARTING
4 DISCONNECT FUEL LINE WHEN NOT IN USE
5 SEE FUEL TANK FOR FUEL INSTRUCTIONS

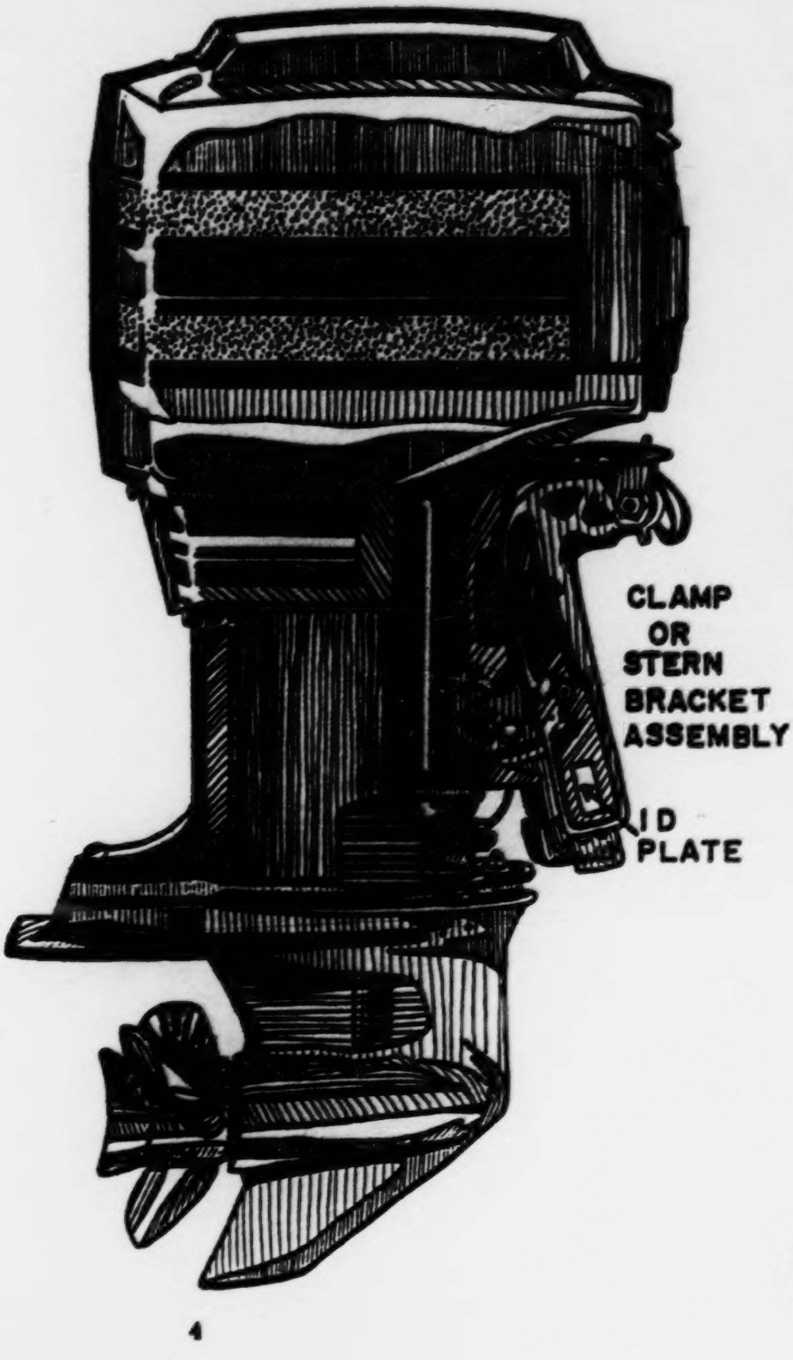
This type of Identification plate is located on the swivel bracket where it is attached to the tilt tube. On older engines which were equipped with clamp assemblies this location is between the clamps.


ID PLATE
SWIVEL BRACKET
CLAMP OR STERN BRACKET ASSEMBLY


SERIAL NUMBER
55041951
MERCURY
MERCURY
MARINE

MODULE 04.01

On newer Mercury engines the identification plate may look like this one and be located on the stern bracket as shown below.


CLAMP
OR
STERN
BRACKET
ASSEMBLY
ID
PLATE

MODULE 04.01

Determining Mercury Year Model

In order to determine the year model on a Mercury Marine engine you will need to know the engine model designation and the serial number. The model designation is usually the engine horsepower and you have just learned where to find the serial number.

The model number is usually located on the motor cover. There are some irregularities in Mercury model designations. They are described below.

> All the way through and including 1978 a "0" was added after the horsepower. A model 1100 would be 110 horsepower. A model 500 would be 50 horsepower.
>
> The exceptions to the add a "0" rule are the following:
> A model 110 is 9.8 hp.
> A model 402 is a 40 hp.
> A model 39 is a 3.9 hp.

From 1979 through to the present the number shown in the graphic on the motor cover on engine cowling indicates the actual horsepower. As an example a model V-300 is a 300hp engine and a model 3.5 is a 3.5 horsepower engine. Exceptions to this are models like the 3.4 Litre and the 2.4 Litre EFI. In these cases the litre designation will appear in the chart.

Once you have determined the engine's model designation, located the identification plate, and recorded the serial number, you are ready to look up the year model.

Take the model and serial number information to the Mercury Marine outboard year model identification chart. It will look like the 1986 example included at the back of this information sheet.

Locate the model designation in the left-most column of the chart. You will notice that there are two serial numbers listed to the right of your model designation for each year in the chart. These columns are for the United States and Canada. Finding that your serial number fell into a column other than the one for the United States would be a rare occurrence in the southern part of the United States. In the north, particularly in the Great Lakes region, it would be more likely to find Canadian serial numbers.

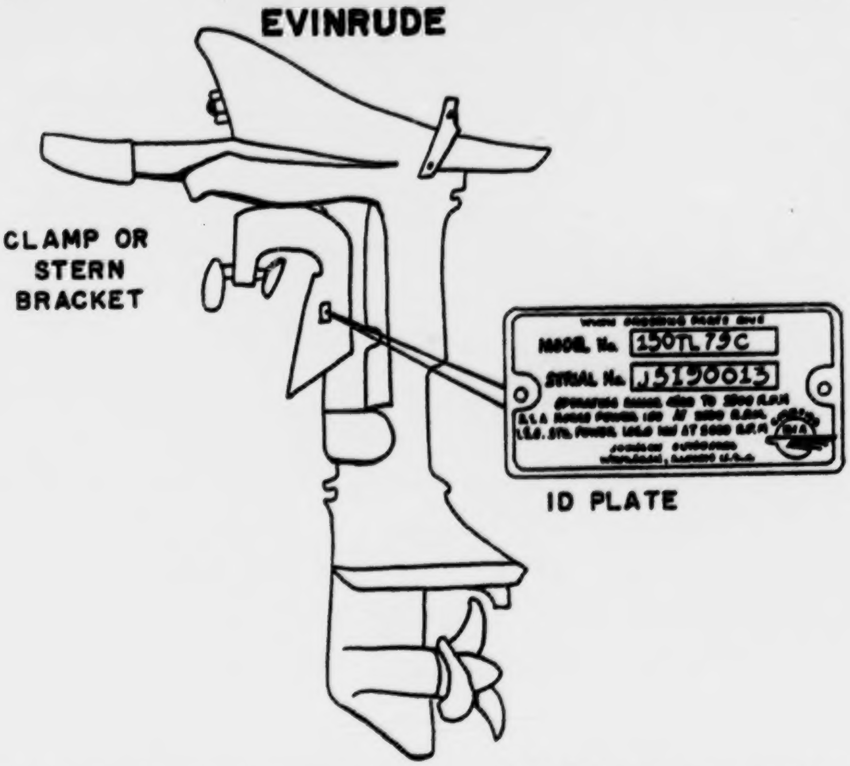
The serial numbers printed in the year model chart are the beginning serial numbers for each model produced in the listed year. For example, the first model 115 produced in 1983 in the United States was serial number 6262961. Since all serial numbers for a particular model run in sequence, the next 1983 model 115 would be number 6262962. The last 1983 model 115 serial number can be obtained by subtracting 1 from the first model 115 serial number for 1984. Looking at the chart, that number would be 6440183 minus 1 or 6440182. All 1983 model 115 engines will have serial numbers in the range 6262961 to 6440182.

After you have located your model designation on the left side of the chart you must locate the year column which has the serial number range containing the number belonging to your model. To do this you must compare your serial number to each of the beginning numbers found in the chart for your model. You will find that your serial number falls between the numbers listed for two model years. The model 115 serial number, 6592147, falls after the beginning number, 6440183, in 1984 and before the beginning number, 6630171, for 1985. It belongs to the range 6440183 to 6630170 in the 1984 column. Since 6592147 was made sometime after the first engine for 1984, (s/n 6440183), and sometime before the first engine for 1985, (s/n 6630171), it is a 1984 model.

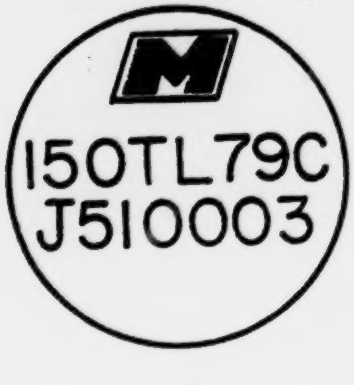
MODULE 04.01

OMC Engine Identification Plates

Most OMC engines have identification plates in two locations. One location is on the stern bracket with a plate that looks something like the one shown below.

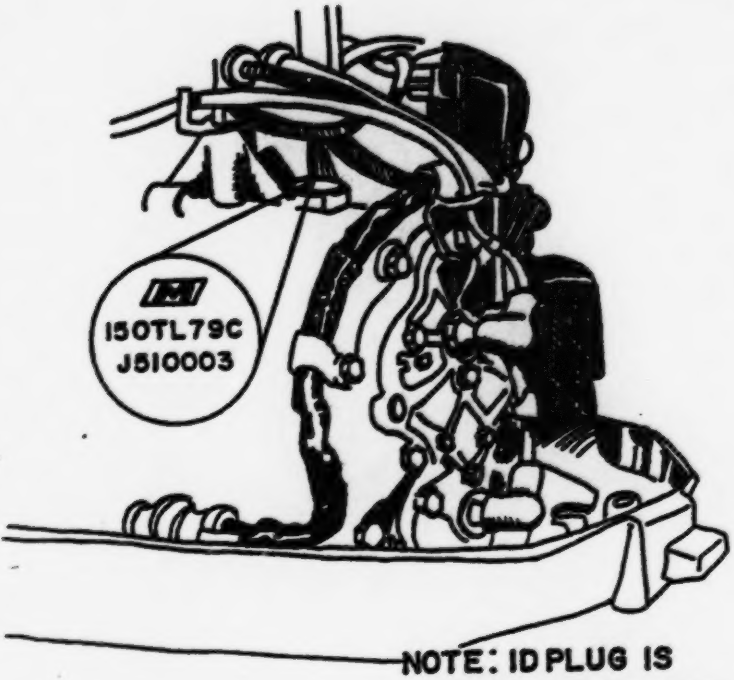

EVINRUDE
CLAMP OR STERN BRACKET
MODEL No.
150TL79C
SERIAL No.
J5190013
ID PLATE

The other location is on the powerhead. This identification plate is in the form of a core plug attached to the powerhead itself. The example shown here is twice actual size.


150TL79C
J510003

MODULE 04.01

The OMC identification core plug can be found by removing the motor cover and looking on the powerhead. The core plug is not in the same spot on all motors. You will have to look for it. Generally, the identification core plug is located somewhere on the upper portion of the powerhead.



NOTE: ID PLUG IS USUALLY ON THE UPPER PORTION OF POWER HEAD

MODULE 04.01

Determining OMC Model Year

OMC, (Outboard Marine Corporation), is the name of the parent company that manufactures Johnson and Evinrude outboard motors. In past years there were some differences between Johnson and Evinrude motors. Most of the differences were in appearance only. The exceptions were some of the motor covers and control boxes. For several years now Johnson and Evinrude motors have been identical except in color and name.

There are two methods of determining the year model of an OMC outboard motor. One method is used for all engines produced before 1980 and involves the use of a chart. The other method is used for all engines produced during and after 1980. It involves the use of a date code found on the identification plate or core plug.

Engines Before 1980

To determine the year model of an OMC engine produced before 1980 you will need to know the horsepower, (hp), the model number, whether it is a Johnson or Evinrude, and have a copy of the OMC Year Model Guide. The horsepower rating of the motor as well as the brand name will usually be found in the graphic on the motor cover. The model number will be found either on the identification plate or on the identification core plug.

After collecting the make, horsepower rating, and model number information you can look up the model year in the Model Year Guide. If your model number starts with a letter it can be looked up alphabetically in the guide. If your model number starts with a digit it can be looked up in numerical sequence.

Engines 1980 and Later

Johnson and Evinrude engines produced in the year 1980 and later use the "INTRODUCES" method for coding the year model into the model number. This method substitutes letters from the word "INTRODUCES" for the last two digits of the year according to the following chart:

I - 1
N - 2
T - 3
R - 4
O - 5
D - 6
U - 7
C - 8
E - 9
S - 0

Using the INTRODUCES method the model numbers are constructed as

MODULE 04.01

follows:

first letter - J or E
next 2 or 3 digits - horsepower
next 1 or 2 letters - engine configuration code
next 2 letters - year model code
remaining letters - not used

Example: J140TLCNB

```
       || ||| |__________ not used
       || |||_____________ year model CN, C for 8, N for 2, = 1982
       || ||______________ long model (20" transom)
       || |________________ TNT, electric start, sport styling
       ||__________________ 140 horsepower
       |___________________ Johnson motor
```

<u>Engine Configuration Codes</u>

CR - Canada, Rope Start
E - electric Start
ER - Electric Start, Sport Styling
L - Long Shaft, (20" transom)
M - Manual Tilt, (V4 electric only)
R - Rope Start
SE - Non-tiller, Electric Start
T - TNT, Electric Start, Sport Styling
W - 110 deg. Angle Drive - weedless
X - Extra Long Shaft, (25" Transom)
TE - Tiller Electric Start

MODULE 04.01

Identifying Outboard Model Year Worksheet

NAME________________________________ **STUDENT NO.**__________________

Go into the shop and locate one example of each of the Mercury Marine and OMC types of engine identification plates. Record below the information found on the plates.

Mercury

1.

2.

OMC

1.

2.

Use the Mercury Marine Year Model Guide provided with the Identifying Outboard Model Year information sheet to determine the model year of the following engines.

	Model	Serial	Model Year
1.	115 hp	6561023	
2.	2.2 hp	8075999	
3.	20 hp	A910972	
4.	50 hp	6571001	
5.	V-175	6628700	

MODULE 04.01

Identify the model year for the following OMC engines.

	Horsepower	Model	Make	Model Year
1.	5.1	470	Evinrude	
2.	25	J25RC1	Johnson	
3.	4	AA	Evinrude	
4.	115	J115TXCN	Johnson	
5.	140	140TLCOS	Evinrude	

MODULE 04.01

Outboard Model Year Worksheet

ANSWER KEY

Mercury Marine

	Model	Serial	Model Year
1.	115 hp	6561023	1984
2.	2.2 hp	8075999	1984
3.	20 hp	A910972	1986
4.	50 hp	6586679	1985
5.	V-175	A919002	1986

OMC

	Horsepower	Model	Make	Model Year
1.	5.1	470	Evinrude	1933
2.	25	J25RC1	Johnson	1981
3.	4	AA	Evinrude	1916-17
4.	115	J115TXCN	Johnson	1982
5.	140	140TLCOS	Evinrude	1985

NAME________________________ STUDENT NO.________________________

04.01 **PERFORMANCE CHECKLIST**

MODULE : Identifying Outboard Model Year

COMPETENCY: Determine the model/year of Mercury Marine and OMC outboard motors.

1. ☐ Found Mercury Marine identification plates
2. ☐ Located Mercury serial numbers
3. ☐ Used Mercury serial number to find model year on chart
4. ☐ Found OMC external identification plates
5. ☐ Found OMC identification core plugs
6. ☐ Identified OMC serial numbers
7. ☐ Identified OMC model numbers
8. ☐ Used chart to find model year for OMC 1909 - 1979 years
9. ☐ Used INTRODUCES to find OMC model year 1980 and up
10. ☐
11. ☐
12. ☐
13. ☐
14. ☐
15. ☐

COMPETENCY ACHIEVED? ☐ YES ☐ NO

EXPLANATION:

OUTBOARD MODEL YEAR IDENTIFICATION U.S. & CANADA

dealer
service guide

SERVICE PROMOTION

The Outboard Model Year Identifications shown on this chart are for 1983 through 1986. For prior years' information on U.S. built outboards, refer to the "Outboard Motor Trade-In Guide Blue Book". It is available from:

ABOS Marine Publications Division
INTERTEC Publishing Corp.
P.O. Box 12901
Overland Park, KS 66212

Merc Model	1986 Models		1985 Models		1984 Models		1983 Models	
	U.S.	Canada	U.S.	Canada	U.S.	Canada	U.S.	Canada
3.4 Litre	A912426		A129445		6436883			
V-300							6239853	
V-200	A913228		6625221		6435503		6203991	
V-175	A918329		6618751					
V-150XR2	A905191							
V-150	A904646		6616991		6443213		6220254	
135	A909997							
115	A907777	A708751	6630171	7220628	6440183	7209483	6262961	7200643
90	A902436	A707926	6623151	7220458	6436123	7208858	6246856	7200518
80							6232941	7200988
75	A197882	A707086	6613221	7219798	6432901	7208573		
70							6279960	7199218
60	A197392	A706911	6609651	7219538	6428681	7208333		
50 (3 Cyl.)	A912478	A709221						
50 (4 Cyl.)			6586624	7218778	6448808	7209693	6275323	7198593
45	A914859	A709616						
40							6228285	7202538
35	A922171	A710196	6626696	7220578	6445653	7209608		
25	A911346	A709071	6593849	7219218	6453343	7209933	6185159	7200418
20	A910971	A708966						
18			6617631	7219868	6443973	7209533	6171607	7200763
9.9	A918999	A708906						
9.8			6620196	7219878	6438338	7208898	6263906	7196018
8	A197112	A708341						
7.5			6611886	7221548	6430041	7208428	6239857	7200028
6	A910596							

(OVER)

Merc Model	1986 Models		1985 Models		1984 Models		1983 Models	
	U.S.	Canada	U.S.	Canada	U.S.	Canada	U.S.	Canada
4.5			6608536	7219303	6428076	7208223	6232381	7199408
4	A906702	A708351						
3.5			6594744		6434771		6202173	
2.2	A800761		8087123		8075603			
90cc Sail Power	A907702							
210cc Sail Power	A918999							

MODEL YEAR GUIDE

Johnson

OMC

Evinrude

FORWORD

THIS GUIDE WAS COMPILED FOR DEALERS TO ENABLE THEM TO IDENTIFY THE YEAR AND HORSEPOWER OF EARLIER MODELS – THEREBY MAKING IT SIMPLER FOR THEM TO LOCATE OTHER REFERENCE MATERIAL THEY MAY HAVE PERTAINING TO THE PARTICULAR MODEL. THE SECTIONS ARE ARRANGED IN MODEL NUMBER ORDER WITH LETTERS A TO Z FIRST AND THEN NUMERICALLY (LOW NUMBERS TO HIGH).

THE 80 AND LATER MODEL NUMBERS THAT BEGIN WITH J AND E ARE ARRANGED NUMERICALLY RATHER THAN BY LETTER.

KEEP THIS GUIDE HANDY. YOU WILL FIND IT A VALUABLE, TIME-SAVING PIECE OF REFERENCE LITERATURE.

EVINRUDE OUTBOARDS

MODEL NO.	HP	YEAR	MODEL NO.	HP	YEAR	MODEL NO.	HP	YEAR
A (#3000-7200)	3.5	1915-22	305	25.0	1929	425	5.8	1932-33
A (#60,000 UP)	2.0	1915-28	306	25.0	1929	426	4.0	1932
A (TWIN)	3.0	1923	307	18.0	1928	427	4.0	1932
AA	4.0	1916-17	308	18.0	1928	428	4.0	1932
B (#6000-7200)	3.5	1915-22	309	3.5	1929	429	4.0	1932
B (#65,000 UP)	2.0	1915-28	310	14.0	1930	430	5.8	1932
B (TWIN)	3.0	1923	311	14.0	1930	431	5.8	1932
C	2.0	1916	312	14.0	1930	432	2.2	1933
C (TWIN)	3.0	1924-25	313	14.0	1930	433	2.2	1933
D	2.0	1916	314	30.0	1930	434	2.2	1933
D (TWIN)	3.0	1924-25	315	30.0	1930	436	2.2	1933
E	3.5	1915	335	35.0	1930	437	2.2	1933
EE	4.0	1916	336	40.0	1930	438	2.2	1933
F (#F1001-F4000)	6.0	1928	340	9.0	1929	440	3.0	1933
F (#1F001-4F300)	7.0	1929	344	40.0	1930	441	4.0	1933
G	4.0	1928	348	7.0	1930	442	5.1	1933
H (#H1001-H2500)	12 0	1928	356	7.0	1928	443	5.1	1933
H (#1H001-13H250)	14.0	1929	358	4.0	1931	444	5.1	1933
H (SINGLE)	3.5	1913-14	359	4.0	1931	445	5.1	1933
H (#30,000 UP)	4.0	1926	360	3.5	1931	446	5.1	1933
J	4.0	1927-29	361	13.7	1933	447	1.8	1938
K	4.0	1927-29	362	13.7	1933	448	5.1	1933
L	4.0	1923-26	363	13.7	1933	449	2.8	1938
LA	4.0	1923-26	364	13.7	1933	449	3.0	1939
LAT	4.0	1923-26	365	13.7	1934	450	8.5	1933
N	2.5	1923-28	366	13.7	1934	451	8.5	1933
NF	2.5	1929	367	1.8	1940-41	452	8.5	1933
NS	2.5	1923-27	368	3.0	1940-41	453	8.5	1933
R	4.0	1927	369	3.0	1940-41	454	–	1933
RS	4.0	1927	371	5.0	1940-41	456	8 5	1933
T	8.0	1927	373	5.0	1940-41	457	8.5	1933
TS	8.0	1927	375	15.2	1940-42	458	8.5	1933
U (#U1001-U5200)	16.0	1928	377	1.0	1941	459	8.5	1933
U (#1U001-15U000)	20.0	1929	378	3.3	1941-42	460	5.1	1933
52T	7.0	1925	379	3.3	1941-47	461	5.1	1933
62T	7.0	1926	381	1.0	1946-47	462	5.1	1933
72T	7 0	1927	400	4.0	1931-35	463	1.8	1940
82A	7.0	1928	401	4.0	1931	464	2.2	1933
82B	11.0	1928	402	4.0	1931	465	1.8	1939
92A	7.0	1929	403	2.75	1931	466	5.0	1939
92B	14.0	1929	404	2.75	1931	467	8.5	1939
92BR	14.0	1929	405	4.0	1931	468	5.1	1933
143	20.0	1929-32	406	4.0	1931	469	1.0	1939
146	14.0	1929-33	407	4.0	1932	469	1.0	1940
156	22.0	1930-34	408	4.0	1932	470	5.1	1933
157	22.0	1930-34	409	4.0	1932	471	8.5	1939-41
160	11.0	1930	410	4.0	1932	472	2.2	1933
161	7.0	1930	411	4.0	1932	474	2.2	1933
162	2.75	1930	412	4.0	1932	475	5.0	1940
163	11.0	1930	413	4.0	1932-33	476	4.0	1933
167	22.0	1930	414	4.0	1932-33	477	1.8	1939
168	22.0	1930	415	3.0	1932-34	478	4.0	1933
176	20.0	1930	416	4.0	1932-35	479	4.0	1933
177	–	1930	417	8.0	1932-34	481	–	1933
178	–	1930	418	11.0	1932	483	4.0	1933
179	–	1930	419	11.0	1932	484	4.0	1933
183	2.5	1931	420	5.8	1932-33	489	2.2	1934
300	7.0	1929	421	5.8	1932-33	490	2.2	1935
301	7.0	1929	422	11.0	1932	491	4.0	1935
302	11.0	1929	423	11.0	1932	492	8.5	1935-36
303	11.0	1929	424	5.8	1932-33	492	8.5	1937-38

EVINRUDE OUTBOARDS CONT.

MODEL NO.	HP	YEAR	MODEL NO.	HP	YEAR	MODEL NO.	HP	YEAR
494	4.0	1936	720	36.0	1932	925	18.0	1933
495	4.0	1936-37	721	36.0	1932	926	18.0	1933
496	8.5	1936-37	722	36.0	1932	927	18.0	1933
497	8.5	1936	723	36.0	1932	2001	25.0	1951-52
498	2.5	1937	724	36.0	1932	2002	25.0	1951-52
499	4.2	1937-38	725	36.0	1932	2003	25.0	1952
499	5.0	1939	726	36.0	1932	2004	25.0	1952
500	11.0	1934-36	728	31.2	1933	3012	3.0	1952-54
500	15.0	1931-33	729	31.2	1933	3013	3.0	1952-54
600	21.0	1931	730	31.2	1933	3014	3.0	1955
601	25.0	1931-33	731	31.2	1933	3015	3.0	1955
602	25.0	1931-33	732	31.2	1933	3016	3.0	1955
603	25.0	1931-33	733	31.2	1933	3018	3.0	1956
604	25.0	1931-33	734	31.2	1933	3019	3.0	1956
605	25.0	1931-33	735	31.2	1933	3020	3.0	1956
606	25.0	1931-33	800	40.0	1931	3022	3.0	1957
607	25.0	1931-33	801	40.0	1931	3023	3.0	1957
608	25.0	1931-33	802	40.0	1931	3024	3.0	1957
609	–	1931	803	40.0	1931	3026	3.0	1958
610	–	1931	804	–	1931	3027	3.0	1958
615	21.0	1931-32	806	40.0	1931	3028	3.0	1958
616	21.0	1931-32	807	40.0	1931	3030	3.0	1959
617	21.0	1931-32	808	40.0	1931	3031	3.0	1959
618	25.0	1932	809	40.0	1931	3032	3.0	1959
619	25.0	1932	810	40.0	1931	4000	2.2	1934
620	25.0	1932	811	40.0	1931	4001	2.2	1934
621	25.0	1932	812	40.0	1931	4002	2.2	1934
624	25.0	1932	813	40.0	1931	4003	2.2	1934
625	25.0	1932	814	40.0	1932	4004	2.2	1934
626	25.0	1932	815	40.0	1932	4005	2.2	1934
627	25.0	1932	816	40.0	1932	4006	2.2	1934
630	–	1932	817	40.0	1932	4007	2.2	1934
631	–	1932	818	40.0	1932	4008	2.2	1934
634	21.1	1933	819	40.0	1932	4009	2.2	1934
635	21.1	1933	820	40.0	1932	4010	2.2	1934
636	21.1	1933	821	40.0	1932	4011	2.2	1934
637	21.1	1933	822	40.0	1932	4012	2.2	1934
638	21.1	1933	823	40.0	1932	4013	2.2	1934
639	21.1	1933	824	40.0	1932	4014	2.2	1934
640	21.1	1933	825	40.0	1932	4015	2.2	1934
641	21.1	1933	826	–	1932	4016	4.0	1934
642	–	1933	827	–	1932	4017	4.0	1934
643	–	1933	828	–	1933	4018	4.0	1934
700	35.0	1931	829	–	1933	4019	4.0	1934
701	35.0	1931	900	18.0	1931	4020	5.1	1934
702	35.0	1931	901	18.0	1931	4021	5.1	1934
703	35.0	1931	902	18.0	1931	4022	5.1	1934
704	35.0	1931	903	18.0	1931	4023	5.1	1934
705	35.0	1931	905	12.0	1931-33	4024	5.1	1934
706	35.0	1931	906	12.0	1931-33	4025	5.1	1934
707	35.0	1931	907	12.0	1931-33	4026	5.1	1934
708	35.0	1931	912	18.0	1932	4027	5.1	1934
709	35.0	1931	913	18.0	1932	4028	–	1934
710	35.0	1931	914	18.0	1932	4029	–	1934-36
711	35.0	1931	915	18.0	1932	4030	5.5	1934
715	36.0	1932	920	18.0	1933	4031	5.5	1934
716	36.0	1932	921	18.0	1933	4032	5.5	1934
717	36.0	1932	922	18.0	1933	4033	5.5	1934
718	36.0	1932	923	18.0	1933	4034	8.5	1934
719	36.0	1932	924	18.0	1933	4035	8.5	1934

EVINRUDE OUTBOARDS CONT.

MODEL NO.	HP	YEAR	MODEL NO.	HP	YEAR	MODEL NO.	HP	YEAR
4036	8.5	1934	4097	4.6	1935	4164	4.3	1936
4037	8.5	1934	4098	4.6	1935	4165	5.0	1936
4038	8.5	1934	4099	4.6	1935	4166	5.0	1936
4039	8.5	1934	4101	4.6	1935	4167	5.0	1936
4040	8.5	1934	4102	5.0	1935	4168	5.0	1936
4041	8.5	1934	4103	5.0	1935	4169	5.0	1936
4042	9.2	1934-35	4104	5.0	1935	4171	5.0	1936
4043	9.2	1934-35	4105	5.0	1935	4172	5.0	1936
4044	9.2	1934-35	4106	5.0	1935	4173	5.0	1936
4045	9.2	1934-35	4107	5.0	1935	4174	5.0	1936
4046	9.2	1934-35	4108	5.0	1935	4175	5.0	1936
4047	9.2	1934-35	4109	5.0	1935	4176	5.0	1936
4048	9.2	1934-35	4111	9.2	1935	4177	5.0	1936
4049	9.2	1934-35	4112	9.2	1935	4178	9.2	1936
4050	5.5	1934	4113	9.2	1935	4179	9.2	1936
4051	5.5	1934	4114	9.2	1935	4180	9.2	1936
4052	5.5	1934	4115	9.2	1935	4181	9.2	1936
4053	5.5	1934	4116	9.2	1935	4182	9.2	1936
4054	5.5	1934	4117	9.2	1935	4183	9.2	1936
4055	5.5	1934	4118	9.2	1935	4184	–	1936
4056	5.5	1934	4119	–	1935	4185	9.2	1936
4057	5.5	1934	4121	4.0	1935	4186	9.2	1936
4058	2.2	1934	4122	4.0	1935	4187	9.2	1936
4059	2.2	1934	4123	4.0	1935	4188	9.2	1936
4060	2.2	1934	4124	4.0	1935	4189	9.2	1936
4061	2.2	1934	4125	4.0	1935	4190	9.2	1936
4062	2.2	1934	4126	4.0	1935	4191	9.2	1936
4063	2.2	1934	4127	4.6	1935	4192	4.4	1936-38
4064	2.2	1934	4128	4.6	1935	4193	4.3	1936
4065	2.2	1934	4129	5.0	1935	4194	4.4	1936
4066	4.0	1934	4131	5.0	1935	4195	1.4	1936
4067	4.0	1934	4132	5.0	1935	4196	4.7	1936
4068	4.0	1934	4133	5.0	1935	4197	4.7	1936
4069	4.0	1934	4134	9.2	1935	4198	4.7	1936
4070	5.5	1934	4135	9.2	1935	4199	9.2	1936
4071	5.5	1934	4136	9.2	1935	4200	9.2	1936
4072	5.5	1934	4137	9.2	1935	4201	0.9	1937
4073	5.5	1934	4138	4.0	1935	4203	0.9	1937
4074	5.5	1934	4139	1.5	1935	4205	1.4	1937
4075	5.5	1934	4142	4.6	1935	4206	1.4	1937
4076	9.2	1934	4143	4.0	1935	4207	1.6	1937
4077	9.2	1934	4144	4.0	1935	4208	1.6	1937
4078	2.2	1934	4144	4.3	1936	4209	2.5	1937
4079	2.2	1934	4145	1.4	1936-37	4211	2.5	1937
4080	2.2	1934	4146	1.5	1936	4212	2.5	1937
4081	2.2	1934	4147	1.5	1936	4213	2.5	1937
4082	4.0	1934	4148	4.4	1936	4214	4.3	1937
4083	4.0	1934	4149	4.4	1936	4215	4.3	1937
4084	4.0	1934	4151	4.3	1936	4216	4.3	1937
4085	4.0	1934	4152	4.4	1936	4217	4.3	1937
4086	5.5	1934	4153	4.7	1936	4218	4.3	1937
4087	5.5	1934	4154	4.7	1936	4219	9.2	1937
4088	9.2	1934	4155	4.7	1936	4221	4.7	1937
4089	9.2	1934	4156	2.5	1936	4222	4.7	1937
4091	1.6	1935	4157	2.5	1936	4223	4.7	1937
4092	4.0	1935	4158	2.5	1936	4224	4.7	1937
4093	4.0	1935	4159	2.5	1936	4225	4.7	1937
4094	4.0	1935	4161	4.3	1936	4226	4.7	1937
4095	4.0	1935	4162	4.3	1936	4227	4.4	1937
4096	4.0	1935	4163	4.3	1936	4228	4.4	1937

EVINRUDE OUTBOARDS CONT.

MODEL NO.	HP	YEAR	MODEL NO.	HP	YEAR	MODEL NO.	HP	YEAR
4229	4.3	1937	4296	2.0	1939	4367	2.0	1941-42
4231	9.2	1937	4297	2.0	1939	4368	3.3	1941-46
4232	9.2	1937	4298	2.0	1939	4369	3.3	1941-46
4233	9.2	1937	4299	2.0	1939	4371	3.3	1941-46
4234	9.2	1937	4301	1.8	1939	4372	3.3	1941-46
4235	9.2	1937	4302	1.8	1939	4373	9.7	1942
4236	9.2	1937	4303	3.3	1939	4374	9.7	1942
4237	9.2	1937	4304	3.3	1939	4375	9.7	1943
4238	9.2	1937	4305	3.3	1939	4376	9.7	1943
4239	9.2	1937	4306	3.3	1939	4377	9.7	1943
4241	9.2	1937	4307	3.0	1939	4378	5.4	1945-46
4242	9.2	1937	4308	3.0	1939	4379	5.4	1945-46
4243	9.2	1937	4309	5.4	1939	4381	5.4	1945-46
4244	–	1937	4311	5.4	1939	4382	5.4	1945-46
4245	9.2	1937	4312	5.4	1939	4383	9.7	1945-49
4246	9.2	1937	4313	5.0	1939-41	4384	9.7	1945-49
4247	9.2	1937	4314	5.0	1939-41	4385	9.7	1945-49
4248	9.2	1937	4315	9.7	1939	4386	9.7	1945-49
4249	9.2	1937	4316	9.7	1939	4387	9.7	1945-49
4251	4.4	1937	4317	9.7	1939	4388	9.7	1945-49
4252	1.1	1938	4318	9.7	1939	4389	9.7	1945-49
4253	1.1	1938	4319	9.7	1939	4391	9.7	1945-49
4254	2.0	1938	4321	9.7	1939	4392	9.7	1945-49
4255	2.0	1938	4322	9.7	1939-42	4393	9.7	1945 49
4256	1.8	1938	4323	9.7	1939-42	4394	9.7	1945-49
4257	1.8	1938	4324	9.7	1939-42	4395	9.7	1945-49
4258	3.0	1938	4325	9.7	1939-42	4398	9.7	1946
4259	3.0	1938	4326	9.7	1939-42	4402	5.4	1946-48
4261	2.8	1938	4327	9.7	1939-42	4403	5.4	1946-48
4262	2.8	1938	4328	–	1939-41	4404	5.4	1946-48
4263	0.5	1939-41	4329	1.8	1939	4405	5.4	1946-48
4264	0.5	1939-41	4331	1.8	1939	4406	1.1	1946-47
4265	1.1	1939-41	4332	3.0	1939-	4407	1.1	1946-47
4266	1.1	1938-41	4333	3.0	1939	4409	2.0	1946
4267	4.7	1938	4334	1.1	1939-41	4411	2.0	1946
4268	4.7	1938	4335	8.5	1939-41	4412	2.0	1946
4269	4.7	1938	4336	8.5	1939-41	4413	2.0	1946
4271	9.2	1938	4337	5.0	1939-41	4414	2.0	1947
4272	9.2	1938	4338	5.0	1939-41	4415	2.0	1947
4273	9.2	1938	4339	5.0	1939-41	4416	2.0	1947
4274	9.2	1938	4341	5.0	1940-41	4417	2.0	1947
4275	9.2	1938	4346	2.0	1940	4418	3.3	1947
4276	9.2	1938	4347	2.0	1940	4419	3.3	1947
4277	9.2	1938	4348	2.0	1940	4421	3.3	1947
4278	9.2	1938	4349	2.0	1940	4422	3.3	1947
4279	9.2	1938	4351	1.8	1940-41	4423	3.3	1947-51
4281	9.2	1938	4352	1.8	1940-41	4424	3.3	1947-51
4282	9.2	1938	4353	3.3	1940	4425	1.5	1948-51
4283	9.2	1938	4354	3.3	1940	4429	5.4	1949
4284	–	1938	4355	3.3	1940	4431	5.4	1949
4285	2.0	1938	4356	3.3	1940	4432	5.0	1949
4286	2.0	1938	4357	3.0	1940	4434	7.5	1950
4287	3.0	1938	4358	3.0	1940	4435	7.5	1950
4288	3.0	1938	4359	5.4	1940-41	4438	14.0	1950
4289	4.7	1938	4361	5.4	1940-41	4439	14.0	1950
4291	4.7	1938	4362	5.4	1940-41	4441	14.0	1951
4292	4.7	1938	4363	5.4	1940-41	4442	14.0	1951
4293	4.7	1938	4364	2.0	1941-42	4443	7.5	1951-52
4294	4.7	1938	4365	2.0	1941-42	4444	7.5	1951-52
4295	4.7	1938	4366	2.0	1941-42	4447	7.5	1952

EVINRUDE OUTBOARDS CONT.

MODEL NO.	HP	YEAR	MODEL NO.	HP	YEAR	MODEL NO.	HP	YEAR
4448	7.5	1952	7011	31.2	1935	9014	16.2	1935
5101	12.0	1949	7012	31.2	1935	9015	16.2	1936
5102	12.0	1949	7013	31.2	1935	9016	16.2	1936
5512	5.5	1956	7014	31.2	1935	9017	16.2	1936
5513	5.5	1956	7015	31.2	1936	9018	16.2	1936
5514	5.5	1957	7016	31.2	1936	9019	16.2	1936
5515	5.5	1957	7017	31.2	1936	9021	16.2	1936
5516	5.5	1958	7018	31.2	1936	9022	16.2	1937
5517	5.5	1958	7019	31.2	1936	9023	16.2	1937
5518	5.5	1959	7021	31.2	1936	9024	16.2	1937
5519	5.5	1959	7022	33.4	1937	9025	16.2	1937
6000	21.1	1934	7023	33.4	1937	9026	16.2	1938
6001	21.1	1934	7024	33.4	1937	9027	16.2	1938
6002	21.1	1934	7025	33.4	1937	9028	16.2	1938
6003	21.1	1934	7026	33.4	1938	9029	16.2	1938
6004	21.1	1934	7027	33.4	1938	9031	16.2	1939
6005	21.1	1934	7028	33.4	1938	9032	16.2	1939
6006	21.1	1934	7029	33.4	1938	9033	16.2	1939
6007	21.1	1934	7031	33.4	1939-50	9034	16.2	1939
6008	–	1934	7032	33.4	1939-50	9035	17.6	1940-41
6011	21.1	1935	7033	33.4	1939-41	9036	17.6	1940-41
6012	21.1	1935	7034	33.4	1939-41	9037	17.6	1940-41
6013	21.1	1935	7035	33.4	1942	9038	17.6	1940-41
6014	21.1	1935	7512	7.5	1953	9039	15.0	1941
6015	21.1	1935	7513	7.5	1953	9041	17.6	1941
6016	21.1	1935	7514	7.5	1954	10012	10.0	1056
6017	–	1935	7515	7.5	1954	10013	10.0	1956
6018	21.1	1936	7516	7.5	1954	10014	10.0	1957
6019	21.1	1936	7517	7.5	1954	10015	10.0	1957
6021	21.1	1936	7518	7.5	1955	10016	10.0	1958
6022	21.1	1936	7519	7.5	1955	10017	10.0	1958
6023	21.1	1936	7520	7.5	1956	10018	10.0	1959
6024	21.1	1936	7521	7.5	1956	10049	10.0	1959
6025	–	1936	7522	7.5	1957	15012	15.0	1953-54
6026	22.5	1937	7523	7.5	1957	15013	15.0	1953-54
6027	22.5	1937	7524	7.5	1958	15014	15.0	1955
6028	22.5	1937	7525	7.5	1958	15015	15.0	1955
6029	22.5	1937	8000	–	1934	15016	15.0	1956
6031	22.5	1937	8001	–	1934	15017	15.0	1956
6032	22.5	1937	8002	–	1935	15020	18.0	1957
6033	–	1937	8003	–	1936	15021	18.0	1957
6034	22.5	1938	8004	–	1937	15024	18.0	1958
6035	22.5	1938	8005	–	1938	15025	18.0	1958
6036	22.5	1938	8006	–	1939-41	15028	18.0	1959
6037	22.5	1938	8008	50.0	1943	15029	18.0	1959
6038	–	1938	8014	50.0	1946	15918	15.0	1956
6039	22.5	1939-50	8015	50.0	1949	15919	15.0	1956
6041	22.5	1939-50	9000	16.2	1934	15922	18.0	1957
6042	–	1939-40	9001	16.2	1934	15923	18.0	1957
6043	–	1941	9002	16.2	1934	15926	18.0	1958
7000	31.2	1934	9003	16.2	1934	15927	18.0	1958
7001	31.2	1934	9004	16.2	1934	25012	25.0	1953-54
7002	31.2	1934	9005	16.2	1934	25013	25.0	1953-54
7002	31.2	1934	9006	16.2	1934	25014	25.0	1954
7004	31.2	1934	9007	16.2	1934	25015	25.0	1954
7005	31.2	1934	9008	16.2	1935	25018	25.0	1955
7006	31.2	1934	9009	16.2	1935	25019	25.0	1955
7007	31.2	1934	9011	16.2	1935	25022	30.0	1956
7008	31.2	1935	9012	16.2	1935	25023	30.0	1956
7009	31.2	1935	9013	16.2	1935	25028	35.0	1957

EVINRUDE OUTBOARDS CONT.

MODEL NO.	HP	YEAR
25029	35.0	1957
25034	35.0	1958
25035	35.0	1958
25526	30.0	1956
25527	30.0	1956
25532	35.0	1957
25533	35.0	1957
25916	25.0	1954
25917	25.0	1954
25920	25.0	1955
25921	25.0	1955
25924	30.0	1956
25925	30.0	1956
25930	35.0	1957
25931	35.0	1957
25936	35.0	1958
25937	35.0	1958
35012	35.0	1959
35013	35.0	1959
35514	35.0	1958
35515	35.0	1958
35516	35.0	1959
35517	35.0	1959
50012	50.0	1958
50013	50.0	1958
50016	50.0	1959
50017	50.0	1959
50514	50.0	1958
50515	50.0	1958
50518	50.0	1959
50519	50.0	1959
50816	50.0	1959
50817	50.0	1959

1960 AND LATER

MODEL NO.	HP	YEAR
1002	1.5	1970
1802	1.5	1968
1902	1.5	1969
2102	2.0	1971
2202	2.0	1972
2302	2.0	1973
2402	2.0	1974
2502	2.0	1975
2602	2.0	1976
2702	2.0	1977
2802	2.0	1978
2902	2.0	1979
E2RCS	2.0	1980
E2RCI	2.0	1981
E2RCN	2.0	1982
3034	3.0	1960
3035	3.0	1960
3036	3.0	1960
3038	3.0	1961
3039	3.0	1961
3040	3.0	1961
3042	3.0	1962
3043	3.0	1962
3044	3.0	1962
3302	3.0	1963
3303	3.0	1963
3312	3.0	1963
3402	3.0	1964
3403	3.0	1964
3412	3.0	1964
3432	3.0	1964
3433	3.0	1964
3502	3.0	1965
3503	3.0	1965
3512	3.0	1965
3532	3.0	1965
3533	3.0	1965
3602	3.0	1966
3603	3.0	1966
3606	3.0	1966
3612	3.0	1966-67
3632	3.0	1966
3633	3.0	1966
3636	3.0	1966
3702	3.0	1967
3703	3.0	1967
3706	3.0	1967
3707	3.0	1967
3712	3.0	1967
3716	3.0	1967
3732	3.0	1967
3733	3.0	1967
3736	3.0	1967
3737	3.0	1967
3802	3.0	1968
3803	3.0	1968
3806	3.0	1968
3807	3.0	1968
3832	3.0	1968
3833	3.0	1968
3836	3.0	1968
3837	3.0	1968
4006	4.0	1970
4036	4.0	1970
4106	4.0	1971
4136	4.0	1971
4206	4.0	1972
4236	4.0	1972
4306	4.0	1973
4336	4.0	1973
4406	4.0	1974
4436	4.0	1974
4506	4.0	1975
4536	4.0	1975
4606	4.0	1976
4636	4.0	1976
4706	4.0	1977
4736	4.0	1977
4806	4.0	1978
4836	4.0	1978
4837	4.0	1978
4902	4.0	1969
4904	4.0	1979
4906	4.0	1969
4932	4.0	1979
4933	4.0	1979
4936	4.0	1969
E4WCI	4.0	1981
E4WCN	4.0	1982
E4WCS	4.0	1980
E48RHCI-E48RHLCI	4.5	1981
E48RCI	4.0	1981
E48RLCI	4.0	1981
E48RCN-E48RLCN	4.0	1982
E48RHCN	4.0	1982
E48RHLCN	4.0	1982
E4RLCS	4.0	1980
E5RCS	4.5	1980
E5RLCS	4.5	1980
E5RHCS	4.5	1980
E5RHLCS	4.5	1980
E5RCI	4.5	1981
E5RLCI	4.5	1981
E5RCN-E5RLCN	4.5	1982
E5RHCI	4.5	1981
E5RHLCI	4.5	1981
E5RHCN-E5RHLCN	4.5	1982
5302	5.5	1963
5303	5.5	1963
5402	5.5	1964
5403	5.5	1964
5502	5.0	1965
5503	5.0	1965
5520	5.5	1960
5521	5.5	1960
5522	5.5	1961
5523	5.5	1961
5524	5.5	1962
5525	5.5	1962
5602	5.0	1966
5603	5.0	1966
5702	5.0	1967
5703	5.0	1967
5802	5.0	1968
5803	5.0	1968
6002	6.0	1970
6003	6.0	1970
6102	6.0	1971
6202	6.0	1972
6203	6.0	1972
6302	6.0	1973
6303	6.0	1973
6402	6.0	1974
6403	6.0	1974
6502	6.0	1965
6503	6.0	1965
6504	6.0	1975
6505	6.0	1975
6602	6.0	1966
6603	6.0	1966
6604	6.0	1976
6605	6.0	1976
6702	6.0	1967
6703	6.0	1967
6704	6.0	1977

EVINRUDE OUTBOARDS CONT.

MODEL NO.	HP	YEAR	MODEL NO.	HP	YEAR	MODEL NO.	HP	YEAR
6706	6.0	1977	10725	9.9	1977	E15RCI	15	1981
802	6.0	1968	10754	9.9	1977	E15RLCI	15	1981
803	6.0	1968	10755	9.9	1977	E15RCN-E15RLCN	15	1982
6804	6.0	1978	10822	9.5	1968	E15ECI	15	1981
6805	6.0	1978	10824	9.9	1978	E15ECN	15	1982
6902	6.0	1969	10825	9.9	1978	18002	18	1970
6903	6.0	1969	10835	9.9	1978	18003	18	1970
6904	6.0	1979	10854	9.9	1978	18102	18	1971
6905	6.0	1979	10855	9.9	1978	18103	18	1971
E8RCS	7.5	1980	10924	9.9	1979	18202	18	1972
E8RLCS	7.5	1980	10925	9.9	1979	18203	18	1972
E8RCI	7.5	1981	10935	9.9	1979	18302	18	1963
E8RLCI	7.5	1982	10954	9.9	1979	18303	18	1963
E8RCN-E8RLCN	7.5	1982	10955	9.9	1979	18304	18	1973
E8SRLCN	7.5	1982	E10ECS	9.9	1980	18305	18	1973
9022	9.5	1970	E10ELCS	9.9	1980	18402	18	1964
9023	9.5	1970	E10ELCI	9.9	1981	18403	18	1964
9122	9.5	1971	E10ELCN	9.9	1982	18502	18	1965
9123	9.5	1971	E10RCI	9.9	1981	18503	18	1965
9222	9.5	1972	E10RLCI	9.9	1981	18602	18	1966
9223	9.5	1972	E10RCN-E10RLCN	9.9	1982	18603	18	1966
9322	9.5	1973	E10RCS	9.9	1980	18702	18	1967
9323	9.5	1973	E10RLCS	9.9	1980	18703	18	1967
9422	9.5	1964	E10SELCI	9.9	1981	18802	18	1968
9423	9.5	1964	E10SELCN	9.9	1982	18803	18	1968
9622	9.5	1965	E10SELCS	9.9	1980	18902	18	1969
9623	9.5	1965	15032	18	1960	18903	18	1969
9622	9.5	1966	15033	18	1960	E20CRCN	20	1982
9623	9.5	1966	15034	18	1961	E20CRLCN	20	1982
9722	9.5	1967	15035	18	1961	25002	25	1970
723	9.5	1967	15036	18	1962	25003	25	1970
9822	9.5	1968	15037	18	1962	25102	25	1971
9823	9.5	1968	15404	15	1974	25103	25	1971
9922	9.5	1969	15405	15	1974	25202	25	1972
9923	9.5	1969	15454	15	1974	25203	25	1972
10020	10	1960	15455	15	1974	25252	25	1972
10021	10	1960	15504	15	1975	25253	25	1972
10022	10	1961	15505	15	1975	25302	25	1973
10023	10	1961	15554	15	1975	25303	25	1973
10024	10	1962	15555	15	1975	25352	25	1973
10025	10	1962	15604	15	1976	25353	25	1973
10302	10	1963	15605	15	1975	25402	25	1974
10303	10	1963	15654	15	1976	25403	25	1974
10422	9.5	1964	15655	15	1976	25452	25	1974
10424	9.9	1974	15704	15	1977	25453	25	1974
10425	9.9	1974	15705	15	1977	25502	25	1975
10454	9.9	1974	15754	15	1977	25503	25	1975
10455	9.9	1974	15755	15	1977	25552	25	1975
10522	9.5	1965	15804	15	1978	25553	25	1975
10524	9.9	1975	15805	15	1978	25602	25	1976
10525	9.9	1975	15854	15	1978	25603	25	1976
10554	9.9	1975	15855	15	1978	25652	25	1976
10555	9.9	1975	15904	15	1979	25653	25	1976
10622	9.5	1966	15905	15	1979	25702	25	1977
10624	9.9	1976	15954	15	1979	25703	25	1977
10625	9.9	1976	15955	15	1979	25752	25	1977
10654	9.9	1976	E15RCS	15	1980	25753	25	1977
10655	9.9	1976	E15RLCS	15	1980	25802	25	1978
722	9.5	1967	E15ECS	15	1980	25803	25	1978
24	9.9	1977	E15ELCS	15	1980	25852	25	1978

EVINRUDE OUTBOARDS CONT.

MODEL NO.	HP	YEAR	MODEL NO.	HP	YEAR	MODEL NO.	HP	YEAR
25853	25	1978	35023	40	1961	40363	40	1963
25902	25	1969	35028	40	1962	40372	40	1963
25903	25	1969	35029	40	1962	40373	40	1963
25904	25	1979	35520	40	1960	40402	40	1964
25906	25	1979	35521	40	1960	40403	40	1964
25952	25	1979	35524	40	1961	40404	40	1974
25953	25	1979	35525	40	1961	40405	40	1974
E25RCS	25	1980	35530	40	1962	40452	40	1964
E25RLCS	25	1980	35531	40	1962	40453	40	1964
E25TECS	25	1980	35602	35	1976	40454	40	1974
E25TELCS	25	1980	35603	35	1976	40455	40	1974
E25RCI	25	1981	35652	35	1976	40462	40	1964
E25RLCI	25	1981	35653	35	1976	40463	40	1964
E25RCN-E25RLCN	25	1982	35702	35	1977	40472	40	1964
E25ECI	25	1981	35703	35	1977	40473	40	1964
E25ELCI	25	1981	35752	35	1977	40502	40	1965
E25ECN-E25ELCN	25	1982	35753	35	1977	40503	40	1965
E25TECI	25	1981	35802	35	1978	40504	40	1975
E25TECN	25	1982	35803	35	1978	40505	40	1975
E25TELCI	25	1981	35852	35	1978	40552	40	1965
E25TELCN	25	1982	35853	35	1978	40553	40	1965
E25RWCI	25	1981	35902	35	1979	40554	40	1975
E25RWLCI	25	1981	35903	35	1979	40555	40	1975
E25RWCN	25	1982	35932	40	1962	40562	40	1965
E25RWLCN	25	1982	35933	40	1962	40563	40	1965
28202	28	1962	35952	35	1979	40572	40	1965
28203	28	1962	35953	35	1979	40573	40	1965
28302	28	1963	E35RCI	35	1981	40602	40	1966
28303	28	1963	E35RLCI	35	1981	40603	40	1966
28352	28	1963	E35RCN-E35RLCN	35	1982	40604	40	1976
28402	28	1964	E35RCS	35	1980	40605	40	1976
28403	28	1964	E35RLCS	35	1980	40652	40	1966
28452	28	1964	E35ECI	35	1981	40653	40	1966
33002	33	1970	E35ELCI	35	1981	40654	40	1976
33003	33	1970	E35ECN-E35ELCN	35	1982	40655	40	1976
33052	33	1970	E35ECS	35	1980	40662	40	1966
33053	33	1970	E35ELCS	35	1980	40663	40	1966
33502	33	1965	40002	40	1970	40672	40	1966
33503	33	1965	40003	40	1970	40673	40	1966
33552	33	1965	40052	40	1970	40702	40	1967
33553	33	1965	40053	40	1970	40703	40	1967
33602	33	1966	40072	40	1970	40752	40	1967
33603	33	1966	40073	40	1970	40753	40	1967
33652	33	1966	40102	40	1971	40772	40	1967
33653	33	1966	40103	40	1971	40773	40	1967
33702	33	1967	40152	40	1971	40802	40	1968
33703	33	1967	40153	40	1971	40803	40	1968
33752	33	1967	40202	40	1972	40852	40	1968
33753	33	1967	40203	40	1972	40853	40	1968
33802	33	1968	40252	40	1972	40872	40	1968
33803	33	1968	40253	40	1972	40873	40	1968
33852	33	1968	40302	40	1963	40902	40	1969
33853	33	1968	40303	40	1963	40903	40	1969
33902	33	1969	40304	40	1973	40952	40	1969
33903	33	1969	40305	40	1973	40953	40	1969
33952	33	1969	40352	40	1963	40972	40	1969
33953	33	1969	40353	40	1963	40973	40	1969
35018	40	1960	40354	40	1973	E40RWCI E40RWLCI	40	1981
35019	40	1960	40355	40	1973	E40RWCN	40	1982
35022	40	1961	40362	40	1963	E40RWLCN	40	1982

EVINRUDE OUTBOARDS CONT.

MODEL NO.	HP	YEAR	MODEL NO.	HP	YEAR	MODEL NO.	HP	YEAR
E48CELCS	48	1980	60062	60	1970	75432	75	1964
50172	50	1971	60063	60	1970	75433	75	1964
50173	50	1971	60072	60	1970	75462	75	1964
50202	50	1972	60073	60	1970	75463	75	1964
50203	50	1972	60162	60	1971	75482	75	1964
50272	50	1972	60163	60	1971	75483	75	1964
50273	50	1972	60172	60	1971	75492	75	1964
50302	50	1973	60173	60	1971	75493	75	1964
50303	50	1973	60432	60	1964	75532	75	1965
50372	50	1973	60433	60	1964	75533	75	1965
50373	50	1973	60462	60	1964	75542	75	1975
50442	50	1974	60463	60	1964	75543	75	1975
50443	50	1974	60532	60	1965	75552	75	1965
50472	50	1974	60533	60	1965	75553	75	1965
50473	50	1974	60552	60	1965	75582	75	1965
50514	50	1958	60553	60	1965	75583	75	1965
50518	50	1959	60632	60	1966	75592	75	1965
50522	75	1960	60633	60	1966	75593	75	1965
50523	75	1960	60652	60	1966	75642	75	1976
50524	75	1961	60653	60	1966	75643	75	1976
50525	75	1961	60732	60	1967	75742	75	1977
50528	75	1962	60733	60	1967	75743	75	1977
50529	75	1962	60752	60	1967	75842	75	1978
50542	50	1975	60753	60	1967	75843	75	1978
50543	50	1975	E60ECS	60	1980	75942	75	1979
50572	50	1975	E60ELCS	60	1980	75943	75	1979
50573	50	1975	E60ECI	60	1981	E75ERLCI	75	1981
50802	50	1978	E60ECN-E60ELCN	60	1982	E75ERCI	75	1981
50803	50	1978	E60ELCI	60	1981	E75ERCN	75	1982
50902	50	1979	E60TLCI	60	1981	E75ERLCN	75	1982
50903	50	1979	E60TLCN	60	1982	E75ERCS-E75ERLCS	75	1980
50926	75	1961	65272	65	1972	E75TRLCI	75	1981
50927	75	1961	65273	65	1972	E75TRLCN	75	1982
50930	75	1962	65372	65	1973	E75TRLCS	75	1980
50931	75	1962	65373	65	1973	80652	80	1966
E50BECI	50	1981	65832	65	1968	80653	80	1966
E50BELCI	50	1981	65833	65	1968	80682	80	1966
E50BECN-E50BELCN	50	1982	65852	65	1968	80683	80	1966
E50BECS-E50BELCS	50	1980	65853	65	1968	80692	80	1966
E50ECS-E50ELCS	50	1980	70442	70	1974	80693	80	1966
55642	55	1976	70443	70	1974	80752	80	1967
55643	55	1976	70472	70	1974	80753	80	1967
55672	55	1976	70473	70	1974	80792	80	1967
55673	55	1976	70572	70	1975	80793	80	1967
55772	55	1977	70573	70	1975	85093	85	1970
55773	55	1977	70673	70	1976	85193	85	1971
55872	55	1968	70773	70	1977	85293	85	1972
55873	55	1968	70873	70	1978	85393	85	1973
55874	55	1978	70973	70	1979	85493	85	1974
55875	55	1978	E70ELCI	70	1981	85593	85	1975
55902-55903	55	1979	E70ELCN	70	1982	85693	85	1976
55972	55	1969	E70ELCS	70	1980	85699	85	1976
55973	55	1969	E70TLCI	70	1981	85790	85	1977
55974	55	1979	E70TLCN	70	1982	85793	85	1977
55975	55	1979	75352	75	1963	85799	85	1977
E55RLCS	55	1980	75353	75	1963	85852	85	1968
E55RCI	55	1981	75382	75	1963	85853	85	1968
E55RCN	55	1982	75383	75	1963	85890	85	1978
[illegible]55RLCI	55	1981	75392	75	1963	85892	85	1968
E55RLCN	55	1982	75393	75	1963	85893	85	1968

EVINRUDE OUTBOARDS CONT.

MODEL NO.	HP	YEAR	MODEL NO.	HP	YEAR	MODEL NO.	HP	YEAR
85896	85	1978	115899	115	1978	E150TRLCI	150	1981
85899	85	1978	115983	115	1969	E150TRXCI	150	1981
85990	85	1979	115990	115	1979	E150TRLCN	150	1982
85993	85	1969	115993	115	1979	E150TRXCN	150	1982
85995	85	1979	115999	115	1979	175740	175	1977
85999	85	1979	E115MLCS	115	1980	175749	175	1977
E85MLCS	85	1980	E115TLCS	115	1980	175840	175	1978
E85TLCS	85	1980	E115TXCS	115	1980	175849	175	1978
E85TXCS	85	1980	E115MLCI	115	1981	175940	175	1979
90482	90	1964	E115TLCI	115	1981	175949	175	1979
90483	90	1964	E115TXCI	115	1981	E175TRLCS	175	1980
90492	90	1964	E115MLCN	115	1982	E175TRXCS	175	1980
90493	90	1964	E115TLCN	115	1982	E175TRLCI	175	1981
90582	90	1965	E115TXCN	115	1982	E175TRXCI	175	1981
90583	90	1965	125183	125	1971	E175TRLCN	175	1982
90592	90	1965	125283	125	1972	E175TRXCN	175	1982
90593	90	1965	135342	–	1973	200640	200	1976
E90MLCI	90	1981	135383	135	1973	200649	200	1976
E90MLCN	90	1982	135443	135	1974	200740	200	1977
E90TLCI	90	1981	135483	135	1974	200749	200	1977
E90TLCN	90	1982	135489	135	1974	200840	200	1978
E90TXCI	90	1981	135643	135	1975	200849	200	1978
E90TXCN	90	1982	135683	135	1975	200940	200	1979
95683	100	1966	135689	135	1975	200949	200	1979
95693	100	1966	135643	135	1976	E200TRLCS	200	1980
100193	100	1971	135683	135	1976	E200TRXCS	200	1980
100293	100	1972	140740	140	1977	E200TRLCI	200	1981
100782	100	1957	140743	140	1977	E200TRXCI	200	1981
100783	100	1967	140783	140	1977	E200TRLCN	200	1982
100882	100	1968	140840	140	1978	E200TRXCN	200	1982
100883	100	1968	140843	140	1978	235840	235	1978
100990	100	1979	140883	140	1978	235849	235	1978
100993	100	1979	140940	140	1979	235940	235	1979
100999	100	1979	140943	140	1979	235949	235	1979
E100MLCS	100	1980	140983	140	1979	E235TRLCS	235	1980
E100TLCS	100	1980	E140MLCS	140	1980	E235TRXCS	235	1980
E100TXCS	100	1980	E140TRLCS	140	1980	E235TRLCI	235	1981
115083	115	1970	E140TRXCS	140	1980	E235TRXCI	235	1981
115393	115	1973	E140MLCI	140	1981	E235TRLCN	235	1982
115493	115	1974	E140MLCN	140	1982	E235TRXCN	235	1982
115499	115	1974	E140TRLCI	140	1981	EB12	Trolling motor	1974-76
115593	115	1975	E140TRXCI	140	1981	EB14	Trolling motor	1975-76
115693	115	1976	E140TRLCN	140	1982	EB52	Trolling motor	1977-82
115699	115	1976	E140TRXCN	140	1982	EB54	Trolling motor	1977-82
115742	115	1967-68	150840	150	1978	EB82	Trolling motor	1977-82
115790	115	1977	150849	150	1978	EB84	Trolling motor	1977-81
115793	115	1977	150940	150	1979	EBH4	Trolling motor	1980-82
115799	115	1977	150949	150	1979	EBL52	Trolling motor	1981-82
115890	115	1978	E150TRLCS	150	1980	EBL84	Trolling motor	1981-82
115893	115	1978	E150TRXCS	150	1980	ET12	Trolling motor	1975-76
						ET14	Trolling motor	1975-76

EVINRUDE COMMERCIAL OUTBOARDS

MODEL NO.	HP	YEAR	MODEL NO.	HP	YEAR	MODEL NO.	HP	YEAR
E4RST	4	1981	E9RSXCSA	9	1980	E25RSCSA	25	1980
E4RSLT	4	1981	E9KCCSC	9	1980	E25RSLCSA	25	1980
E4RSY-E4RSLY	4	1982	E9KCLCSC	9	1980	E25RSA	25	1981
6834B	6	1978	E9KCXCSC	9	1980	E25RSLA	25	1981
6835B	6	1978	E10RSG-2	10	1981	E35RSP	35	1981
6934E	6	1979	E10RSLG-2	10	1981	E35RSLP	35	1981
6935E	6	1979	E10RSW-E10RSLW	10	1982	40804B	40	1978
6912S	6	1979	12802S	12	1978	40805B	40	1978
6913S	6	1979	12803S	12	1978	40904E	40	1979
E6RSCSD	6	1980	12800S	12	1978	40905E	40	1979
E6RSLCSD	6	1980	12902C-R	12	1979	E40RSCSD	40	1980
E6KCCSC	6	1980	12903C-R	12	1979	E40RSLCSD	40	1980
E6KCLCSC	6	1980	2900R	12	1979	E40RSD-R	40	1981
E6RSM	6	1981-82	12912S	12	1979	E40RSLD-R	40	1981
E6RSLM	6	1981-82	12913S	12	1979	E40RSR-E40RSLR	40	1982
E6KCH	6	1981-82	12910S	12	1979	50832C-G	50	1978
E6KCLH	6	1981-82	E12RSCSA	12	1980	50833C-G	50	1978
E7RSF	6.5	1981	E12RSLCSA	12	1980	50932R	50	1979
E7RSLF	6.5	1981	E12RSXCSA	12	1980	50933R	50	1979
9802S	9	1978	E12KCCSC	12	1980	E55RSCSA	55	1980
9803S	9	1978	E12KCLCSC	12	1980	E55RSLCSA	55	1980
9800S	9	1978	E12KCXCSC	12	1980	E55RSJ-E55RSLJ	55	1982
9902C-R	9	1979	E14RSE-E14RSLE	14	1982	E55RSU	55	1981
9903C-R	9	1979	E14RSR-2	14	1981	E55RSLU	55	1981
9900R	9	1979	E14RSLR-2	14	1981			
9912S	9	1979	E15RSP-E15RSLP	15	1982			
9913S	9	1979	25832C	25	1978			
9910S	9	1979	25833C	25	1978			
E9RSCSA	9	1980	25932R	25	1979			
E9RSLCSA	9	1980	25933R	25	1979			

JOHNSON OUTBOARDS

MODEL NO.	HP	YEAR	MODEL NO.	HP	YEAR	MODEL NO.	HP	YEAR
A	2	1922-24	CD-18	5.5	1961	FD-16	18	1962
A-25	2	1925-26	CD-19	5.5	1962	FD-17	18	1963
A-35	2.5	1927-28	CD-20	5.5	1963	FD-18	18	1964
A-45	3	1929	CD-21	5.5	1964	FD-19	18	1965
A-50	4	1930-32	CD-22	6	1965	FD-20	20	1966
A-65	4.1	1933	CD-23	6	1966	FD-21	20	1967
A-70	4.1	1934	CD-24	6	1967	FD-22	20	1968
A-75	4.5	1935	CD-25	6	1968	HA-10	2.5	1940
A-80	4.5	1936	DS-37	2.1	1937	HA-15	2.5	1940
AA-37	4.5	1937	DS-38	2.1	1938	HA-39	2.5	1939
AB-25	2	1925-26	DT-10	5	1940	HD-10	2.5	1940
AD-10	7.5	1956	DT-37	4.2	1937	HD-15	2.5	1940
AD-11	7.5	1957	DT-38	4.2	1938	HD-20	2.5	1941-42
AD-12	7.5	1958	DT-39	5	1939	HD-25	2.5	1946-50
AT-10	5	1940	E-10	15	1956	HD-26	2.5	1951
AT-39	5	1939	E-11	18	1957	HD-39	2.5	1939
BN	2	1922-24	E-12	18	1958	HS-10	2.5	1940
CD-10	5.5	1954	F-70	3.3	1934	HS-15	2.5	1940
CD-11	5.5	1954	F-75	3.3	1935	HS-20	2.5	1941-42
CD-12	5.5	1955	FD-10	15	1956	J-25	1.5	1925-32
CD-13	5.5	1956	FD-11	18	1957	J-65	1.4	1933
CD-14	5.5	1957	FD-12	18	1958	J-70	1.4	1934
CD-15	5.5	1958	FD-13	18	1959	J-75	1.4	1935
D-16	5.5	1959	FD-14	18	1960	J-80	1.7	1936
D-17	5.5	1960	FD-15	18	1961	JH-19	3	1964

JOHNSON OUTBOARDS CONT.

MODEL NO.	HP	YEAR	MODEL NO.	HP	YEAR	MODEL NO.	HP	YEAR
JH-20	3	1965	MQ-12	9.5	1966	RD-23	40	1961
JH-21	3	1966	MQ-13	9.5	1967	RD-24	40	1962
JH-22	3	1967	MQ-14	9.5	1968	RD-25	40	1963
JHF-22	3	1967	OA-55	3	1931	RD-26	40	1964
JH-23	3	1968	OA-60	3	1932	RD-27	40	1965
JHF-21	3	1967	OA-65	2.8	1933	RD-28	40	1966
JHF-23	3	1968	OB-65	2.8	1933	RD-29	40	1967
JW-10	3	1952-54	OB-70	2.8	1934	RD-30	40	1968
JW-11	3	1965	OK-55	8	1931	RDE-16	25	1954
JW-12	3	1966	OK-60	7	1932	RDE-17	25	1955
JW-13	3	1967	OK-75	8.1	1935	RDE-18	30	1956
JW-14	3	1958	P-30	6	1926	RDE-19	35	1957
JW-15	3	1959	P-35	8	1927	RDE-19C	35	1958
JW-16	3	1960	P-40	13.15	1928	RDS-20	35	1958
JW-17	3	1961-62	P-45	12	1929	RDS-21	35	1959
JW-18	3	1963	P-50	20	1930-32	RDS-22	40	1960
JW-19	3	1964	P-65	21.4	1933	RDS-23	40	1961
JW-20	3	1965	P-70	21.4	1934	RDS-24	40	1962
JW-21	3	1966	P-75	22	1935	RDS-25	40	1963
JW-22	3	1967	P-80	22	1936	RDS-26	40	1964
JWF-21	3	1967	PA-50	20	1930-32	RDS-27	40	1965
JW-23	3	1968	PE-50	20	1930-32	RDS-28	40	1966
JWF-23	3	1968	PO-10	22	1940	RDS-29	40	1967
K-35	6	1927	PO-15	22	1941-50	RDS-30	40	1968
K-40	7.15	1928	PO-37	22	1937	RJE-18	30	1956
K-45	7.15	1929	PO-38	22	1938	RJE-19	35	1957
K-50	8	1930-32	PO-39	22	1939	RK-24	40	1962
K-65	9.2	1933	PR-40	16.5	1928	RK-25	40	1963
K-70	9.2	1934	PR-50	24	1930	RK-26	40	1964
K-75	9.3	1935	PR-55	27	1931	RK-27	40	1965
K-80	9.3	1936	PR-60	27	1932	RK-28	40	1966
KA-10	9.8	1940	PR-65	27	1933	RK-29	40	1967
KA-37	9.3	1937	QD-10	10	1949-50	RK-30	40	1968
KA-38	9.3	1938	QD-11	10	1949-50	RX-10	28	1962
KA-39	9.8	1939	QD-12	10	1951-52	RX-11	28	1963
KD-15	9.8	1941-48	QD-13	10	1951-52	RX-12	28	1964
KR-38	–	1938	QD-14	10	1953	RX-13	33	1965
KR-40	–	1928	QD-15	10	1954	RX-14	33	1966
KR-55	–	1931-37	QD-16	10	1955	RX-15	33	1967
KS-15	9.8	1941-42	QD-17	10	1956	RX-16	33	1968
LD-10	5	1965	QD-18	10	1957	RXE-11	28	1963
LD-11	5	1966	QD-10	10	1958	RXE-12	28	1964
LD-12	5	1967	QD-20	10	1959	RXE-13	33	1965
LD-13	5	1968	QD-21	10	1960	RXE-14	33	1966
LS-37	2.1	1937	QD-22	10	1961	RXE-15	33	1967
LS-38	2.1	1938	QD-23	10	1962	RXE-16	33	1968
LT-10	5	1940	QD-24	10	1963	S-45	13	1929-32
LT-37	4.2	1937	RD-10	25	1951	S-65	13.3	1933
LT-38	4.2	1938	RD-11	25	1951	S-70	13.3	1934
LT-39	5	1939	RD-12	25	1952	SA-50	13.3	1930-32
MD-15	1.5	1940	RD-13	25	1952	SC-10	1.5	1968
MD-20	1.5	1941-42	RD-14	25	1953	SE-50	13.3	1930-32
MD-38	1.1	1938	RD-15	25	1953-54	SD-10	16	1940-42
MD-39	1.1	1939	RD-16	25	1954	SD-15	16	1946-48
MS-15	1.5	1940	RD-17	25	1955	SD-20	16	1949-50
MS-20	1.5	1941-42	RD-18	30	1956	SR-38	–	1938
MS-38	1.1	1938	RD-19	35	1957	SR-45	16	1929
MS-39	1.1	1939	RD-19C	35	1958	SR-50	16	1930
MQ-10	9.5	1964	RD-21	35	1959	SR-55	18	1931
MQ-11	9.5	1965	RD-22	40	1960	SR-60	–	1932

JOHNSON OUTBOARDS CONT.

MODEL NO.	HP	YEAR	MODEL NO.	HP	YEAR	MODEL NO.	HP	YEAR
TD-15	5	1941-42	100	1.7	1936	6R69-6RL69	6	1969
TD-20	5	1946-49	110	1.7	1937	6R70-6RL70	6	1970
TN-25	5	1950-51	200	3.3	1936	6R71-6RL71	6	1971
TN-26	5	1950-51	210	3.3	1937	6R72-6RL72	6	1972
TN-27	5	1950-51	300	3.7	1935-36	6R73-6RL73	6	1973
TN-28	5	1952-53	1R69	1.5	1969	6R74-6RL74	6	1974
TS-15	5	1941-42	1R70	1.5	1970	6R75-6RL75	6	1975
TS-20	5	1946	2R71	2	1971	6R76-6RL76	6	1976
TR-10	55	1968	2R72	2	1972	6R77-6RL77	6	1977
TR-40	25.75	1928-29	2R73	2	1973	6R78-6RL78	6	1978
V-45	26	1929-32	2R74	2	1974	6R79-6RL79	6	1979
V-65	26.1	1933	2R75	2	1975	J8RCS	7.5	1980
V-70	26.1	1934	2R76	2	1976	J8RLCS	7.5	1980
VA-50	26.1	1930-32	2R77	2	1977	J8RCI	7.5	1981
VE-50	26.1	1930-32	2R78	2	1978	J8RLCI	7.5	1981
VR-45	32	1929	2R79	2	1979	J8RCN-J8RLCN	7.5	1982
VR-50	32	1930	J2RCS	2	1980	J8SRLCN	7.5	1982
VR-55	36	1931	J2RCI	2	1981	9R69-9RL69	9.5	1969
VX-10	60	1964	J2RCN	2	1982	9R70-9RL70	9.5	1970
VX-11	60	1965	4R69-4RL69	4	1969	9R71-9RL71	9.5	1971
VX-12	60	1966	4R70-4RL70	4	1970	9R72-9RL72	9.5	1972
VX-13	60	1967	4R71-4RL71	4	1971	9R73-9RL73	9.5	1973
VX-14	65	1968	4R72-4RL72	4	1972	10E74-10EL74	9.9	1974
VXH-10	60	1964	4R73-4RL73	4	1973	10R74-10RL74	9.9	1979
VXH-11	60	1965	4R74-4RL74	4	1974	10E75-10EL75	9.9	1975
VXH-12	60	1966	4R75-4RL75	4	1975	10R75-10RL75	9.9	1975
VXH-13	60	1967	4R76-4RL76	4	1976	10E76-10EL76	9.9	1976
VXH-14	65	1968	4R77-4RL77	4	1977	10R76-10RL76	9.9	1976
V4-10	50	1958	4R78-4RL78	4	1978	10E77-10EL77	9.9	1977
V4-11	50	1959	4R79-4RL79	4	1979	10R77-10RL77	9.9	1977
4A-13	75	1961	4W69	4	1969	10E78-10EL78	9.9	1978
V4A-14	75	1962-63	4W70-4WL70	4	1970	10R78-10RL78	9.9	1978
V4A-15	75	1962-63	4W71-4WL71	4	1971	10SEL78	9.9	1978
V4A-16	75	1964	4W72	4	1972	10E79-10EL79	9.9	1979
V4A-17	75	1965	4W73	4	1973	10R79-10RL79	9.9	1979
V4A-18	80	1966	4W74	4	1974	10SEL79	9.9	1979
V4A-19	80	1967	4W75	4	1975	J10ECS	9.9	1980
V4A-20	85	1968	4W76	4	1976	J10ELCS	9.9	1980
V4H-16	75	1964	4W77	4	1977	J10RCS	9.9	1980
V4H-17	75	1965	4W78	4	1978	J10RLCS	9.9	1980
V4H-18	75	1966	4W79	4	1979	J10SELCS	9.9	1980
V4M-10	90	1964	J4RLCS	4	1980	J10SELCI	9.9	1981
V4M-11	90	1965	J4WCS	4	1980	J10RCI	9.9	1981
V4ML-12	100	1966	J4WCN	4	1982	J10RLCI	9.9	1981
V4S-10	50	1958	J48RHCI-J48RHLCI	4	1981	J10ELCI	9.9	1981
V4S-11	50	1959	J4WCI	4	1981	J10RCN-J10RLCN	9.9	1982
V4S-12	75	1960	J48RCI-J48RLCI	4	1981	J10ELCN	9.9	1982
V4S-13	75	1961	J48RCN-J48RLCN	4	1982	J10SELCN	9.9	1982
V4S-14	75	1962	J48RHCN	4	1982	15E74-15EL74	15	1974
V4S-15	75	1963	J48RHLCN	4	1982	15R74-15RL74	15	1974
V4S-16	75	1964	J5RCS	4.5	1980	15E75-15EL75	15	1975
V4S-17	75	1965	J5RHCS	4.5	1980	15R75-15RL75	15	1975
V4S-18	80	1966	J5RHLCS	4.5	1980	15E76-15EL76	15	1976
V4S-19	80	1967	J5RLCS	4.5	1980	15R76-15RL76	15	1976
V4S-20	85	1968	J5RCI	4.5	1981	15E77-15EL77	15	1977
V4T-13	100	1967	J5RLCI	4.5	1981	15R77-15RL77	15	1977
V4TL-13	100	1967	J5RHCI	4.5	1981	15E78-15EL78	15	1978
V4T-14	100	1968	J5RHLCI	4.5	1981	15R78-15RL78	15	1978
TL-14	100	1968	J5RHCN-J5RHLCN	4.5	1982	15E79-15EL79	15	1979
5	–	1931	J5RCN-J5RLCN	4.5	1982	15R79-15RL79	15	1979

JOHNSON OUTBOARDS CONT.

MODEL NO.	HP	YEAR	MODEL NO.	HP	YEAR	MODEL NO.	HP	YEAR
J15ECS	15	1980	35R78-35RL78	35	1978	J55RLCI	55	1981
J15ELCS	15	1980	35E79-35EL79	35	1979	60ES70-60ESL70	60	1970
J15RCS	15	1980	35R79-35RL79	35	1979	60ES71-60ESL71	60	1971
J15RLCS	15	1980	J35ECS	35	1980	J60ECN-J60ELCN	60	1982
J15ECI	15	1981	J35ELCS	35	1980	J60ECS	60	1980
J15RCI	15	1981	J35RCS	35	1980	J60ELCS	60	1980
J15RLCI	15	1981	J35RLCS	35	1980	J60ECI	60	1981
J15RCN-J15RLCN	15	1982	J35ECI	35	1981	J60ELCI	60	1981
J15ECN	15	1982	J35ELCI	35	1981	J60TLCI	60	1981
J20CRCN-J20CRLCN	20	1982	J35ECN-J35ELCN	35	1982	J60TLCN	60	1982
20R69-20RL69	20	1969	J35RCI	35	1981	65ES72-65ESL72	65	1972
20R70-20RL70	20	1970	J35RLCI	35	1981	65ESLR72	65	1972
20R71-20RL71	20	1971	J35RCN-J35RLCN	35	1982	65ESR73-65ESLR73	65	1973
20R72-20RL72	20	1972	40R69-40RL69	40	1969	65ES73-65ESL73	65	1973
20R73-20RL73	20	1973	40E69-40EL69	40	1969	70ES74-70ESL74	70	1974
25R69-25RL69	25	1969	40ES69-40ESL69	40	1969	70ESLR74	70	1974
25R70-25RL70	25	1970	40R70-40RL70	40	1970	70ES75-70ESL75	70	1975
25R71-25RL71	25	1971	40E70-40EL70	40	1970	70EL76	70	1976
25E72-25EL72	25	1972	40ES70-40ESL70	40	1970	70EL77	70	1977
25R72-25RL72	25	1972	40E71-40EL71	40	1971	70EL78	70	1978
25E73-25EL73	25	1973	40R71-40RL71	40	1971	70EL79	70	1979
25R73-25RL73	25	1973	40E72-40EL72	40	1972	J70ELCS	70	1980
25E74-25EL74	25	1974	40R72-40RL72	40	1972	J70ELCI	70	1981
25R74-25RL74	25	1974	40E73-40EL73	40	1973	J70TLCI	70	1981
25E75-25EL75	25	1975	40R73-40RL73	40	1973	J70ELCN	70	1982
25R75-25RL75	25	1975	40E74-40EL74	40	1974	J70TLCN	70	1982
25E76-25EL76	25	1976	40R74-40RL74	40	1974	75ESR75-75ESLR75	75	1975
25R76-25RL76	25	1976	40E75-40EL75	40	1975	75ER76-75ELR76	75	1976
25E77-25EL77	25	1977	40R75-40RL75	40	1975	75ER77-75ELR77	75	1977
25R77-25RL77	25	1977	40E76-40EL76	40	1976	75ER78-75ELR78	75	1978
25E78-25EL78	25	1978	40R76-40RL76	40	1976	75ER79-75ELR79	75	1979
25R78-25RL78	25	1978	J40RWCI-J40RWLCI	40	1981	J75ERCS	75	1980
25E79-25EL79	25	1979	J40RWCN	40	1982	J75ECN-J75ELCN	75	1982
25R79-25RL79	25	1979	J40RWLCN	40	1982	J75ERLCS	75	1980
J25RCS	25	1980	J48CELCS	48	1980	J75TRLCS	75	1980
J25RLCS	25	1980	J50BECI	50	1981	J75ERCI	75	1981
J25TECS	25	1980	J50BELCI	50	1981	J75ERLCI	75	1981
J25TELCS	25	1980	J50BECN-J50BELCN	50	1982	J75TRLCI	75	1981
J25ECI	25	1981	J50BECS-J50BELCS	50	1980	J75TLCN	75	1982
J25ELCI	25	1981	50ES71-50ESL71	50	1971	85ESL69	85	1969
J25ECN-J25ELCN	25	1982	50ES72-50ESL72	50	1972	85ESL70	85	1970
J25RCI	25	1981	50ES73-50ESL73	50	1973	85ESL71	85	1971
J25RLCI	25	1981	50ES74-50ESL74	50	1974	85ESL72	85	1972
J25RCN-J25RLCN	25	1982	50ES75-50ESL75	50	1975	85ESL73	85	1973
J25RWCI	25	1981	50R72-50RL72	50	1972	85ESL74	85	1974
J25RWLCI	25	1981	50R73-50RL73	50	1973	85ESL75	85	1975
J25RWCN	25	1982	50R77-50RL77	50	1977	85EL76	85	1976
J25RWLCN	25	1982	50R78-50RL78	50	1978	85ETLR76	85	1976
J25TECI	25	1981	50R79-50RL79	50	1979	85EL77	85	1977
J25TELCI	25	1981	J50ECS	50	1980	85ETLR77	85	1977
J25TECN-J25TELCN	25	1982	J50ELCS	50	1980	85TXLR77	85	1977
33E69-33EL69	33	1969	55ES69	55	1969	85ML78	85	1978
33R69-33RL69	33	1969	55E76-55EL76	55	1976	85ETLR78	85	1978
33E70-33EL70	33	1970	55E77-55EEL77	55	1977	85TXLR78	85	1978
33R70-33RL70	33	1970	55E78-55EL78	55	1978	85ML79	85	1979
35E76-35EL76	35	1976	55E79-55EL79	55	1979	85TL79	85	1979
35R76-35RL76	35	1976	55R79-55RL79	55	1979	85TXL79	85	1979
35E77-35EL77	35	1977	J55RCN-J55RLCN	55	1982	J85MLCS	85	1980
35R77-35RL77	35	1977	J55RLCS	55	1980	J85TLCS	85	1980
35E78-35EL78	35	1978	J55RCI	55	1981	J85TXCS	85	1980

JOHNSON OUTBOARDS CONT.

MODEL NO.	HP	YEAR	MODEL NO.	HP	YEAR	MODEL NO.	HP	YEAR
J90MLCI	90	1981	135ESL75	135	1975	J175TLCI	175	1981
J90MLCN	90	1982	135ETL75	135	1975	J175TXCI	175	1981
J90TLCI	90	1981	135EL76	135	1976	J175TLCN	175	1982
J90TLCN-J90TXCN	90	1982	135ETL76	135	1976	J175TXCN	175	1982
J90TXCI	90	1981	140ML77	140	1977	200TL76	200	1976
100ESL71	100	1971	140TL77	140	1977	200TXL76	200	1976
100ESL72	100	1972	140TXL77	140	1977	200TL77	200	1977
100ML79	100	1979	140ML78	140	1978	200TXL77	200	1977
100TLR79	100	1979	140TL78	140	1978	200TL78	200	1978
100TXLR79	100	1979	140TXL78	140	1978	200TXL78	200	1978
J100MLCS	100	1980	140ML79	140	1979	200TL79	200	1979
J100TRLCS	100	1980	140TL79	140	1979	200TXL79	200	1979
J100TRXCS	100	1980	140TXL79	140	1979	J200TLCS	200	1980
115ESL69	115	1969	J140MLCS	140	1980	J200TXCS	200	1980
115ESL70	115	1970	J140MLCI	140	1981	J200TLCI	200	1981
115ESL73	115	1973	J140MLCN	140	1982	J200TXCI	200	1981
115ETL74	115	1974	J140TLCS	140	1980	J200TLCN	200	1982
115ESL74	115	1974	J140TXCS	140	1980	J200TXCN	200	1982
115ESL75	115	1975	J140TLCI	140	1981	235TL78	235	1978
115ETL75	115	1975	J140TXCI	140	1981	235TXL78	235	1978
115EL76	115	1976	J140TLCN	140	1982	235TL79	235	1979
115ETL76	115	1976	J140TXCN	140	1982	235TXL79	235	1979
115EL77	115	1977	150TL78	150	1978	J235TLCS	235	1980
115ETL77	115	1977	150TXL78	150	1978	J235TXCS	235	1980
115TXL77	115	1977	150TL79	150	1979	J235TLCI	235	1981
115ML78	115	1978	150TXL79	150	1979	J235TXCI	235	1981
115ETL78	115	1978	J150TLCS	150	1980	J235TLCN	235	1982
115TXL78	115	1978	J150TXCS	150	1980	J235TXCN	235	1982
115ML79	115	1979	J150TLCI	150	1981	E2B	Trolling motor	1975-76
115TL79	115	1979	J150TXCI	150	1981	E2BS	Trolling motor	1974
115TXL79	115	1979	J150TLCN	150	1982	E2T	Trolling motor	1975-76
J115MLCS	115	1980	J150TXCN	150	1982	E4B	Trolling motor	1975-76
J115MLCI	115	1981	175TL77	175	1977	E4H	Trolling motor	1980-82
J115MLCN	115	1982	175TXL77	175	1977	E4T	Trolling motor	1975-76
J115TLCS	115	1980	175TL78	175	1978	E25	Trolling motor	1977-82
J115TXCS	115	1980	175TXL78	175	1978	E28	Trolling motor	1977-82
J115TLCI	115	1981	175TL79	175	1979	E45	Trolling motor	1977-82
J115TXCI	115	1981	175TXL79	175	1979	E48	Trolling motor	1977-81
J115TLCN	115	1982	J175TLCS	175	1980	EL25	Trolling motor	1981-82
J115TXCN	115	1982	J175TXCS	175	1980	EL48	Trolling motor	1981-82
125ESL71	125	1971						
125ESL72	125	1972						
135ESL73	135	1973						
135ESL74	135	1974						
135ETL74	135	1974						

JOHNSON COMMERCIAL OUTBOARDS

MODEL NO.	HP	YEAR	MODEL NO.	HP	YEAR	MODEL NO.	HP	YEAR
J4RST	4	1981	J6RSLCSD	6	1980	9RL78S	9	1978
J4RSLT	4	1981	J6KCCSC	6	1980	9RXL78S	9	1978
J4RSY-J4RSLY	4	1982	J6KCLCSC	6	1980	9R79C-R	9	1979
6RS78B	6	1978	J6RSM	6	1981-82	9RL79C-R	9	1979
6RSL78B	6	1978	J6RSLM	6	1981-82	9RXL79R	9	1979
6RS79E	6	1979	J6KCH	6	1981-82	9K79S	9	1979
6RSL79E	6	1979	J6KCLH	6	1981-82	9KL79S	9	1979
6K79S	6	1979	J7RSF	6.5	1981	9KXL79S	9	1979
6KL79S	6	1979	J7RSLF	6.5	1981	J9RSCSA	9	1980
J6RSCSD	6	1980	9R78S	9	1978	J9RSLCSA	9	1980

JOHNSON COMMERCIAL OUTBOARDS CONT.

MODEL NO.	HP	YEAR	MODEL NO.	HP	YEAR	MODEL NO.	HP	YEAR
J9RSXCSA	9	1980	J12KCLCSC	12	1980	40RL79E	40	1979
J9KCCSC	9	1980	J12KCXCSC	12	1980	J40RSCSD	40	1980
J9KCLCSC	9	1980	J14RSE-J14RSLE	14	1982	J40RSLCSD	40	1980
J9KCXCSC	9	1980	J14RSR-2	14	1981	J40RSD-R	40	1981
J10RSG-2	10	1981	J14RSLR-2	14	1981	J40RSLD-R	40	1981
J10RSW-J10RSLW	10	1982	J15RSP-J15RSLP	15	1982	50RS78C-G	50	1978
J10RSLG-2	10	1981	25RS78C	25	1978	50RSL78C-G	50	1978
12R78S	12	1978	25RSL78C	25	1978	50RS79R	50	1979
12RL78S	12	1978	25RS79R	25	1979	50RSL79R	50	1979
12RXL78S	12	1978	25RSL79R	25	1979	J55RSCSA	55	1980
12R79C-R	12	1979	J25RSCSA	25	1980	J55RSLCSA	55	1980
12RL79C-R	12	1979	J25RSLCSA	25	1980	J55RSU	55	1981
12RXL79R	12	1979	J25RSA	25	1981	J55RSLU	55	1981
12K79S	12	1979	J25RSLA	25	1981	J55RSJ	55	1982
12KL79S	12	1979	J25RSK-J25RSLK	25	1982	J55RSLJ	55	1982
12KXL79S	12	1979	J35RSP	35	1981			
J12RSCSA	12	1980	J35RSLP	35	1981			
J12RSLCSA	12	1980	40R78B	40	1978			
J12RSXCSA	12	1980	40RL78B	40	1978			
J12KCCSC	12	1980	40R79E	40	1979			

EVINRUDE SNOWMOBILES

MODEL NO.	HP	YEAR	MODEL NO.	HP	YEAR	MODEL NO.	HP	YEAR
E134A	35	1974	E265RC	45	1975	E2005	25	1970-72
E135A	35	1975	E266RA	45	1976	E2010	25	1971-72
E136A-A	35	1976	E266RB	45	1976	E2015	25	1971-72
E136S	35	1976	E1400	14	1965	E2020	30	1972
E144A	40	1974	E1500	25	1970	E2025	30	1972
E145A	40	1975	E1521	27	1972	E2035	30	1973
E146A-A	40	1976	E1522	21	1972	E2035Q	30	1973
E146S	40	1976	E1523	30	1972	E2035RC	35	1973
E164A	50	1974	E1523A	30	1972	E2060	14	1966
E165A	50	1975	E1531	27	1973	E2065	14	1966
E165S	50	1975	E1532	21	1973	E2070	14	1967
E166A-A	50	1976	E1533	30	1973	E2075	14	1967
E166S	50	1976	E1534	32	1973	E2080	16	1968
E244Q	30	1974	E1560	14	1966	E2085	16	1968
E250	25	1970-71	E1570	14	1967	E2090	25	1969
E251C	25	1971	E1580	16	1968	E2093	16	1969
E251HP	32	1971-72	E1590	25	1969	E2095	25	1969
E251M	25	1971-72	E1592	16	1969	E2096	16	1969
E252HP	32	1972	E2000	25	1970	E299000 (E3090)	19.5	1969
E252HPE	32	1972	E2001	25	1970	E299001 (E3890)	23.5	1969
E252M	25	1972						
E253	30	1973						
E254RC	35	1974						
E255RC	35	1975						
E264RC	45	1974						

EVINRUDE AQUANAUTS

MODEL NO.	YEAR
AH-100E	1966-67
AH-101E	1968-70

JOHNSON AIRBUOYS

MODEL NO.	YEAR
AH-100J	1966-67
AH-101J	1968-70

OMC SAIL DRIVES

MODEL NO.	HP	YEAR
15S10S	15	1977
15S10G	15	1977
15S11C	15	1978
15S13A	15	1980-82

JOHNSON SNOWMOBILES

MODEL NO.	HP	YEAR	MODEL NO.	HP	YEAR	MODEL NO.	HP	YEAR
J21-152C	21	1972	J134A	35	1974	J266RA	45	1976
J21-153C	21	1973	J135A	35	1975	J1400	14	1966
J25-200R	25	1970	J136A-A	35	1976	J1560	14	1966
J25-200RS	25	1970	J136S	35	1976	J1570	14	1967
J25-201R	25	1971	J144A	40	1974	J1580	16	1968
J25-201RS	25	1971	J145A	40	1975	J1590	25	1969
J27-152M	27	1972	J146A-A	40	1976	J1592	16	1969
J27-153M	27	1973	J146S	40	1976	J2060	14	1966
J30-152HP	30	1972	J164A	50	1974	J2066	14	1966
J20-152HPA	30	1972	J165A	50	1975	J2070	14	1967
J30-153HP	30	1973	J165S	50	1975	J2075	14	1967
J30-202RS	30	1972	J166A-A	50	1976	J2080	16	1968
J30-203RS	30	1973	J166S	50	1976	J2085	16	1968
J30-203RSQ	30	1973	J244Q	30	1974	J2090	25	1969
J30-253E	30	1973	J250	25	1970	J2093	16	1969
J32-153HP	32	1973	J251M	25	1971	J2095	25	1969
J32-251HP	32	1971	J254RC	35	1974	J2096	16	1969
J32-252HP	32	1972	J255RC	35	1975	J299002	12	1969
J32-252HPE	32	1972	J264RC	45	1974	J299003	17	1969
J35-203RCE	35	1973	J265RC	45	1975	J299004	19	1969
						J299014	23	1969

OMC & EVINRUDE BOATS

MODEL NO.	DESCRIPTION	YEAR	MODEL NO.	DESCRIPTION	YEAR	MODEL NO.	DESCRIPTION	YEAR
27010	16' I/O 155 hp	1970	212501	16' I/O 88 hp	1964	234503	16' I/O 120 hp	1966
37010	16' I/O 155 hp	1970	212502	16' I/O 90 hp	1965-66	234504	16' I/O 120 hp	1967
47010	19' I/O 120 hp	1970	214401	16' I/O 88 hp	1964	234506	16' I/O 120 hp	1969
57010	19' I/O 210 hp	1970	214402	16' I/O 90 hp	1965	234605	16' I/O 120 hp	1968
67010	19' I/O 210 hp	1970	214501	16' I/O 88 hp	1964	302402	14' Outboard	1965
202401	16' Outboard	1964	214502	16' I/O 90 hp	1965	302502	14' Outboard	1965
202402	16' Outboard	1965-66	214503	16' I/O 90 hp	1966	303602	14' Outboard	1965
202501	16' Outboard	1964	214504	16' I/O 90 hp	1967	312402	14' I/O 90 hp	1965
202502	16' Outboard	1965-66	221605	16' I/O 155 hp	1968	312403	14' I/O 90 hp	1966
204401	16' Outboard	1964	223506	16' I/O 155 hp	1969	312604	14' I/O 90 hp	1967
204402	16' Outboard	1965-66	224503	16' I/O 150 hp	1966	312605	14' I/O 90 hp	1968
204501	16' Outboard	1964	224504	16' I/O 155 hp	1967	422403	19' I/O 150 hp	1966
204502	16' Outboard	1965-66	224506	16' I/O 155 hp	1969	433506	19' I/O 120 hp	1969
212401	16' I/O 88 hp	1964	224605	16' I/O 155 hp	1968	441506	19' I/O 210 hp	1969
212402	16' I/O 90 hp	1965-66	231605	16' I/O 120 hp	1968	441605	19' I/O 210 hp	1968
						442403	19' I/O 200 hp	1966
						442604	19' I/O 200 hp	1967
						442605	19' I/O 200 hp	1968

OMC & JOHNSON BOATS

MODEL NO.	DESCRIPTION	YEAR	MODEL NO.	DESCRIPTION	YEAR	MODEL NO.	DESCRIPTION	YEAR
101101E	17' Outboard	1964	121202L	17' I/O 150 hp	1965	222804E	16' I/O 120 hp	1967
101201E	17' Outboard	1964	121301E	17' I/O 150 hp	1964	222805S	16' I/O 155 hp	1968
101202L	17' Outboard	1965	121302L	17' I/O 150 hp	1965	224205S	16' I/O 155 hp	1968
101301E	17' Outboard	1964	124101E	17' I/O 150 hp	1964	224206A	16' I/O 155 hp	1969
101302L	17' Outboard	1965	124201E	17' I/O 150 hp	1964	232803R	16' I/O 150 hp	1966
111101T	17' I/O 88 hp	1964	124202L	17' I/O 150 hp	1965	232804E	16' I/O 120 hp	1967
111201T	17' I/O 88 hp	1964	124301E	17' I/O 150 hp	1964	232805S	16' I/O 120 hp	1968
111202L	17' I/O 88 hp	1965	124302L	17' I/O 150 hp	1965	233806A	16' I/O 155 hp	1969
111301L	17' I/O 88 hp	1965	131101E	17' I/O 110 hp	1964	234205S	16' I/O 120 hp	1968
111301T	17' I/O 88 hp	1964	131201E	17' I/O 110 hp	1964	234206A	16' I/O 120 hp	1969
112101T	17' I/O 88 hp	1964	131202L	17' I/O 120 hp	1966	312205S	14' I/O 90 hp	1968
112201T	17' I/O 88 hp	1964	131301E	17' I/O 110 hp	1964	312703R	14' I/O 90 hp	1966
114101T	17' I/O 88 hp	1964	131302L	17' I/O 120 hp	1966	312704E	14' I/O 90 hp	1967
114201T	17' I/O 88 hp	1964	134101T	17' I/O 110 hp	1964	424203R	19' I/O 150 hp	1966
114202L	17' I/O 88 hp	1965	134201T	17' I/O 110 hp	1964	433205S	19' I/O 120 hp	1968
114301T	17' I/O 88 hp.	1964	134202L	17' I/O 120 hp	1965-66	433206A	19' I/O 120 hp	1969
114302L	17' I/O 88 hp	1965	134301T	17' I/O 110 hp	1964	434204E	19' I/O 120 hp	1968
115301T	17' I/O 88 hp	1964	134302L	17' I/O 120 hp	1965-66	442206A	19' I/O 210 hp	1969
121101E	17' I/O 150 hp	1964	222206A	16' I/O 155 hp	1969	444203R	19' I/O 200 hp	1966
121201E	17' I/O 150 hp	1964	222803R	16' I/O 120 hp	1966	444204E	19' I/O 200 hp	1967
						444204T	19' I/O 200 hp	1967
						444205L	19' I/O 210 hp	1968
						444205S	19' I/O 210 hp	1968

EVINRUDE TRAILERS

MODEL NO.	DESCRIPTION	YEAR	MODEL NO.	DESCRIPTION	YEAR	MODEL NO.	DESCRIPTION	YEAR
EB668	16' w/ Brake	1968	975644S	16' w/ Brake	1967	977090R	19' w/ Brake	1966
EB669	16' w/ Brake	1969	975644T	16' w/ Brake	1967	977090T	19' w/ Brake	1967
EB968	19' w/ Brake	1968	975985E	16' w/o Brake	1964	977165R	14' w/ Brake	1966
EB969	19' w/ Brake	1969	975985L	16' w/o Brake	1965	977165T	14' w/ Brake	1967
EN468	14' w/o Brake	1968	975985R	16' w/o Brake	1966			
EN668	16' w/o Brake	1968	975085S	16' w/o Brake	1967			
EN669	16' w/o Brake	1969	975985T	16' w/o Brake	1967			
975644E	16' w/ Brake	1964	976840L	14' w/o Brake	1965			
975644L	16' w/ Brake	1965	976840R	14' w/o Brake	1966			
975644R	16' w/ Brake	1966	976840T	14 w/o Brake	1967			

JOHNSON TRAILERS

MODEL NO.	DESCRIPTION	YEAR	MODEL NO.	DESCRIPTION	YEAR	MODEL NO.	DESCRIPTION	YEAR
JB668S	16' w/ Brake	1968	975695L	17' w/ Brake	1965-66	977091T	19' w/ Brake	1967
JB669A	16' w/ Brake	1969	975696E	17' w/o Brake	1964	977166R	14' w/ Brake	1966
JB968S	19' w/ Brake	1968	975696L	17' w/o Brake	1965-66	977166T	14' w/ Brake	1967-68
JB969A	19' w/ Brake	1969	976870R	16' w/ Brake	1966	990130	16' w/o Brake	1970
JN668S	16' w/o Brake	1968	976870T	16' w/ Brake	1967	990131	16' w/ Brake	1970
JN669A	16' w/o Brake	1969	976871R	16' w/o Brake	1966	990132	19' w/ Brake	1970
975020	17' w/ Brake	1962	976871T	16' w/o Brake	1967			
975390R	17' w/ Brake	1963	976883R	14' w/o Brake	1966			
975600R	17' w/o Brake	1963	976883T	14' w/o Brake	1967-68			
975695E	17' w/ Brake	1964	977091R	19' w/ Brake	1966			

OMC STERN DRIVES

MODEL NO.	HP	YEAR	MODEL NO.	HP	YEAR	MODEL NO.	HP	YEAR
CU & CUE-12M	110	1964	NUFM-12A	90	1970	384SPMRCNC, G	3.8L	–
CU & CUE-13E	120	1965	NUFM-12AX, 13M	90	–	384STMCCNC, G	3.8L	–
CU & CUE-14D	120	1966	NUFM-69R	90	1969	384SPMCCNC, G	3.8L	–
CU & CUE-15S	120	1967	NUFR-12A	90	1970	502STHRCNC, G	5.0L	–
CU & CUE-16C	120	1967-68	NUFR-12AX, 13M	90	–	502SPHRCNC, G	5.0L	–
CUFM-19E	120	1970	NUFR-69R	90	1969	502STHCCNC, G	5.0L	–
CUFM-19EX	120	–	SU & SUE-12M	110	1963-64	502SPHCCNC, G	5.0L	–
CUFM-20D	120	–	SU & SUE-13E	120	1965	502STMRCNC, G	5.0L	–
CUFM-69M, B	120	1969	TU & TUE-14D	200	1966	502SPMRCNC, G	5.0L	–
CUFR-19E	120	1970	TU & TUE-15S	200	1967	502STMCCNC, G	5.0L	–
CUFR-19EX, 20D	120	–	TU & TUE-16C	200	1967-68	502SPMCCNC, G	5.0L	–
CUFR-69M, B	120	1969	TU & TUE-17R	210	1968	504STHRCNC, G	5.0L	–
CUTM-19E	120	1970	TUFM-19E	210	1970	504SPHRCNC, G	5.0L	–
CUTM-19EX, 20D	120	–	TUFM-19EX, 20D	215	–	504STHCCNC, G	5.0L	–
CUTM-69M, B	120	1969	TUFM-21C, 21S	225	–	504SPHCCNC, G	5.0L	–
CUTR-19E	120	1970	TUFM-69M, 69B	210	1969-70	504STMRCNC, G	5.0L	–
CUTR-19EX, 20D	120	–	TUFR-19E, 19EB	210	1970	504SPMRCNC, G	5.0L	–
CUTR-69M, B	120	1969	TUFR-19EX, 20D	215	–	504STMCCNC, G	5.0L	–
DU-10S	80	1962	TUFR-69M	210	1969	504SPMCCNC, G	5.0L	–
DU & DUE-11A	88	1964	VUFM 10C, 10S	120	–	574STHRCNC, G	5.7L	–
DU 11C, 11R	88	1963-64	WUFM-10C	165	–	574SPHRCNC, G	5.7L	–
DU & DUE-12M	90	1965	VUFP-10C	120	–	574STHCCNC, G	5.7L	–
DU & DUE-13B	90	1966	VUFR-10C, 10S	120	–	574SPHCCNC, G	5.7L	–
DU & DUE-14D	90	1967	WUFP-10C	165	–	574STMRCNC, G	5.7L	–
DU & DUE-15S	90	1967-68	XUFM-20C, 20S	235	–	574SPMRCNC, G	5.7L	–
GUFM-10C, 10S	120	–	XUFR-20C, 20S	235	–	574STMCCNC, G	5.7L	–
GUFP-10C	120	–	XUFM 21A, 21R	245	–	574SPMCCNC, G	5.7L	–
GUFR-10C, 10S	120	–	XUFP 21A	245	–	990208F, S	100	–
HU & HUE-12B	150	1964	XUFR-21A, 21R	245	–	990207F, S	120	–
HU & HUE-12M	150	1964	120FTHRCIS, F	120 MODEL	–	990207R, R1, FF	120	–
HU & HUE-13E	150	1965	120STHRCIS, F	120 MODEL	–	990210S, F	165	–
HU-13EM	150	1965	140FTHRCIS, F	140 MODEL	–	990210R, R1	165	–
HU & HUE-14D	150	1966	140STHRCIS, F	140 MODEL	–	990210R2	165	–
HU & HUE-15S	155	1967	140SPHRCIS, F	140 MODEL	–	990211S, F	225	–
HU & HUE-16C	155	1967-68	170STMRCIS, F	3.8L	–	990211R, R1	225	–
HUFM-19E	155	1970	170SPMRCIS, F	3.8L	–	990211A, R11, A1	225	–
HUFM-19EX, 20D	155	–	170STMCCIS, F	3.8L	–	990211M, A11	225	–
HUFM-21C, 21S	155	–	170SPMCCIS, F	3.8L	–	990212S, F	245	–
HUFP-21C	155	–	200FTHRCIS, F	200 MODEL	–	990212R, R1	245	–
HUFM-69M	155	1969	200STHRCIS, F	200 MODEL	–	990212A	245	–
HUFR-19E, EB	155	1970	200SPHRCIS, F	200 MODEL	–	990215S, F	120	–
HUFR-19EX, 20D	155	–	230FTHRCIS, F	230 MODEL	–	990215R, R1, FF	120	–
HUFR-69M	155	1969	230STHRCIS, F	230 MODEL	–	990216S, F	140	–
HUFR, P, M-21S, 21C	155	–	230SPHRCIS, F	230 MODEL	–	990216FF, R, R1	140	–
HUTM-19E	155	1970	252FTHRCNC, G	2.5L	–	990217FF, R, R1	140	–
HUTM-19EX, 20D	155	–	252FPHRCNC, G	2.5L	–	990217S, F	140	–
HUTM-21C, 21S	155	–	252STHRCNC, G	2.5L	–	990218S, F	165	–
HUTM-69M	155	1969	252SPHRCNC, G	2.5L	–	990218R, R1	165	–
HUTP-21C	155	–	260FTHRCIS, F	260 MODEL	–	990218R2	165	–
HUTR-19E	155	1970	260STHRCIS, F	260 MODEL	–	990220R	190	–
HUTR-19EX, 20D	155	–	260SPHRCIS, F	260 MODEL	–	990220R2	190	–
HUTR-69M	155	1969	302FTHRCNC, G	3.0L	–	990221R	170	–
HUTR, P, M-21S, 21C	155	–	302FPHRCNC, G	3.0L	–	990223A, A1	120	–
JUFR, P, M-10S, 10C	165	–	302STHRCNC, G	3.0L	–	990223A11	120	–
KU & KUE-15S	185	1967	302SPHRCNC, G	3.0L	–	990224A, A1	120	–
KU & KUE-16C	185	1968	382STMRCNC, G	3.8L	–	990224A11	120	–
LUFM-10C, 10S	100	–	382SPMRCNC, G	3.8L	–	990225A, A1	140	–
LUFP-10C	100	–	382STMCCNC, G	3.8L	–	990225A11	140	–
LUFR-10C, 10S	100	–	382SPMCCNC, G	3.8L	–	990226A, A1	140	–
NU & NUE-10S	80	1968-69	384STMRCNC, G	3.8L	–	990226A11	140	–

OMC STERN DRIVES CONT.

MODEL NO.	HP	YEAR	MODEL NO.	HP	YEAR	MODEL NO.	HP	YEAR
990227A, A1	165	–	990240M, A11	235	–	990253S, S1	185 MODEL	–
990227A11	165	–	990241A	235	–	990254C, K	230 MODEL	–
990228A, A1	165	–	990241E, G	236	–	990254D, H, J	225	–
990228A11	165	–	990241M, A11	235	–	990254S, S1	230 MODEL	–
990229A	175	–	990242C, C1	120 MODEL	–	990255C, K	230 MODEL	–
990229M, A11	175	–	990242D, H, H1	120	–	990255D, H, J	225	–
990229E	175	–	990242S, S1	120 MODEL	–	990255S, S1, V	230 MODEL	–
990230M, A11	175	–	990243C, C1	120 MODEL	–	990256C, K	260 MODEL	–
990230E	175	–	990243D, H, H1	120	–	990256S, S1	250 MODEL	–
990231A	190	–	990243S, S1	120 MODEL	–	990257C, K	260 MODEL	–
990231M, A11	190	–	990244C, C1	140 MODEL	–	990257S, S1	260 MODEL	–
990231E	190	–	990244D, H, H1	140	–	990260C, K, U	200 MODEL	–
990232M, A11	190	–	990244S, S1	140 MODEL	–	990260S, S1	200 MODEL	–
990234M	120	–	990245C, C1	140 MODEL	–	990261C, K, U	230 MODEL	–
990234E	120	–	990245D, H, H1	140	–	990261S, S1	230 MODEL	–
990235M	120	–	990245S, S1	140 MODEL	–	990262C, K, U	260 MODEL	–
990235E	120	–	990250D, H, J, N, P, U	240	–	990262S, S1	260 MODEL	–
990236M	140	–	990250S	250 MODEL	–	990266C, K	200 MODEL	–
990236E	140	–	990251D, H, J, N, U	240	–	990266S, S1	200 MODEL	–
990237M	140	–	990251S	250 MODEL	–	990267C, K	200 MODEL	–
990237E	140	–	990252C, K	185 MODEL	–	990267S, S1	200 MODEL	–
990238M	165	–	990252D, H, J	185				
990239M	165	–	990252S, S1	185 MODEL	–			
990240E, G	235	–	990253C, K	185 MODEL	–			
990240A	235	–	990253D, H, J	185	–			

OMC INBOARDS

MODEL NO.	HP	YEAR	MODEL NO.	HP	YEAR	MODEL NO.	HP	YEAR
AJF1-10B	250	1970-71	TTF1-10B	210	1970-71	990321A	230 LH	–
AJF1-11E	250	–	TTF1-11E	210	–	990321M	230 LH	–
AJF3-10B	250	1970-71	TTF3-10B	210	1970-71	990322A	230 RH	–
AJF3-11E	250	–	TTF3-11E	210	–	990322M, M1	230 RH	–
AJF7-10B	250	1970-71	TTF7-10B	210	1970-71	990323A, A1	260 LH	–
AJF7-11E	250	–	TTF7-11E	210	–	990323M, M1	260 LH	–
AJH1-11E	250	–	TTH1-11E	210	–	990324A, A1	260 RH	–
AJL1-11E	250	–	TTL1-11E	210	–	990324M, M1	260 RH	–
ATF1-10B	250	1970-71	TTS0-11E	210	–	990325A	230 RH	–
ATF1-11E	250	–	990310C, S	225 LH	–	990325M, M1	230 RH	–
ATF3-10B	250	1970-71	990310R, R1	225 LH	–	990326A, A1	260 RH	–
ATF3-11E	250	–	990311C, S	225 RH	–	990326M, M1	260 RH	–
ATF7-10B	250	1970-71	990311R, R1	225 RH	–	990329A	230 LH	–
ATF7-11E	250	–	990312C, S	250 LH	–	990329M, M1	230 LH	–
ATH1-11E	250	–	990312R, R1	250 LH	–	990330A, A1	260 LH	–
ATL1-11E	250	–	990313C, S	250 RH	–	990330M, M1	260 LH	–
ATS0-11E	250	–	990313R, R1	250 RH	–	990332D	305C.I. 2V LH	–
TJH1-11E	210	–	990314C, S	225 LH	–	990332E, E1, E11	305C.I. 2V LH	–
TJF1-10B	210	1970-71	990314R, R1	225 LH	–	990332P	305C.I. 2V LH	–
TJF3-10B	210	1970-71	990315C, S	225 RH	–	990332S	305C.I. 2V LH	–
TJF3-11E	210	–	990315R, R1	225 RH	–	990333D	305C.I. 2V RH	–
TJF7-10B	210	1970-71	990316C, S	250 LH	–	990333E, E1, E11	305C.I. 2V RH	–
TJF7-11E	210	–	990316R, R1	250 LH	–	990333P	305C.I. 2V RH	–
TJL1-11E	210	–	990317C, S	250 RH	–	990333S	305C.I. 2V RH	–
TJF1-11F	210	–	990317R, R1	250 RH	–	990334A	305C.I. 4V LH	–

LH – Left hand rotation
RH – Right hand rotation
C.I. – Cubic inches displacement

2V – 2 venturi carburetor
4V – 4 venturi carburetor
V – V-Drive

OMC INBOARDS CONT.

MODEL NO.	HP	YEAR	MODEL NO.	HP	YEAR	MODEL NO.	HP	YEAR
990334C	305C.I. 4V RH	–	990342D	305C.I. 2V LH	–	990346R, F	350C.I. 4V LH V	–
990334D	305C.I. 4V LH	–	990342E, E1, E11	305C.I. 2V LH	–	990346S	350C.I. RH	–
990334E, E1, E11	305C.I. 4V LH	–	990342P	305C.I. 2V LH	–	990347A	350C.I. 4V RH V	–
990334P	305C.I. 4V LH	–	990342S	305C.I. 2V LH	–	990347C	350C.I. 4V RH V	–
990334R, F	305C.I. 4V LH	–	990343D	305C.I. 2V RH	–	990347D	350C.I. RH	–
990334S	305C.I. 4V LH	–	990343E, E1, E11	305C.I. 2V RH	–	990347E, E1, E11	350C.I. RH	–
990335A	305C.I. 4V RH	–	990343P	305C.I. 2V RH	–	990347P	350C.I. RH	–
990335C	305C.I. 4V RH	–	990343S	305C.I. 2V RH	–	990347R, F	350C.I. 4V RH V	–
990335D	305C.I. 4V RH	–	990344A	305C.I. 4V LH V	–	990347S	350C.I. RH	–
990335E, E1, E11	305C.I. 4V RH	–	990344C	305C.I. 4V LH V	–	990348A	454C.I. 4V LH V	–
990335P	305C.I. 4V RH	–	990344D	305C.I. 4V LH	–	990348C	454C.I. 4V LH V	–
990335R, F	305C.I. 4V RH	–	990344E, E1, E11	305C.I. 4V LH	–	990348D	454C.I. LH	–
990335S	305C.I. 4V RH	–	990344P	305C.I. 4V LH	–	990348E, E1, E11	454C.I. LH	–
990336A	350C.I. 4V LH	–	990344R, F	305C.I. 4V LH V	–	990348P	454C.I. LH	–
990336C	350C.I. 4V LH	–	990344S	305C.I. 4V LH	–	990348R, F	454C.I. 4V LH V	–
990336D	350C.I. LH	–	990345A	305C.I. 4V RH V	–	990348S	454C.I. LH	–
990336E, E1, E11	350C.I. LH	–	990345C	305C.I. 4V RH V	–	990349A	454C.I. 4V RH V	–
990336P	350C.I. LH	–	990345D	305C.I. 4V RH	–	990349C	454C.I. 4V RH V	–
990336P	350C.I. RH	–	990345E, E1, E11	305C.I. 4V RH	–	990349D	454C.I. RH	–
990336R, F	350C.I. 4V LH	–	990345P	305C.I. 4V RH	–	990349E, E1, E11	454C.I. RH	–
990336S	350C.I. LH		990345R, F	305C.I. 4V RH V	–	990349P	454C.I. RH	–
990337A	350C.I. 4V RH	–	990345S	305C.I. 4V RH	–	990349R, F	454C.I. 4V RH V	–
990337C	350C.I. 4V RH	–	990346A	350C.I. 4V LH V	–	990349S	454C.I. RH	–
990337D	350C.I. RH	–	990346C	350C.I. 4V LH V	–			
990337E, E1, E11	350C.I. RH	–	990346D	350C.I. RH	–			
990337R, F	350C.I. 4V RH	–	990346E, E1, E11	350C.I. RH	–			
990337S	350C.I. RH	–	990346P	350C.I. RH	–			
990338A	454C.I. 4V LH	–						
990338C	454C.I. 4V LH	–						
990338D	454C.I. LH	–						
990338E, E1, E11	454C.I. LH	–						
990338P	454C.I. LH	–						
990338R, F	454C.I. 4V LH	–						
990339A	454C.I. 4V RH	–						
990339C	454C.I. 4V RH	–						
990339D	454C.I. RH	–						
990339E, E1, E11	454C.I. RH	–						
990339P	454C.I. RH	–						
990339R, F	454C.I. 4V RH	–						
990339S	454C.I. RH	–						

LH – Left hand rotation
RH – Right hand rotation
C.I – Cubic inches displacement

2V – 2 venturi carburetor
4V – 4 venturi carburetor
V – V Drive

MODULE 04.02

USING SERVICE MANUALS AND BULLETINS **INSTRUCTOR GUIDE**

COMPETENCY:
Select service manuals and service bulletins to obtain information on service and maintenance procedures and specifications.

INSTRUCTIONAL OBJECTIVES:

The student will be able to:
1. Select Mercury Marine service manuals according to engine model and serial number.
2. Select OMC service manuals according to engine model and model year.
3. Look up service procedures in Mercury Marine and OMC service manuals.
4. Use Mercury Marine and OMC Service Bulletins to learn about service information not contained in the service manuals.
5. Repair and maintain service manuals and bulletins.

LEARNING ACTIVITIES:
1. Participate in class lectures and discussions. (Objectives 1 - 5)
2. Read and study the Information Sheet "Selecting Mercury Marine and OMC Service Manuals and Service Bulletins"

EVALUATION/CHECK-OUT:
The instructor will observe your selection and use of service manuals and bulletins as you work on projects in the shop and record your performance on the Service Manuals and Bulletins Performance Checklist.

RESOURCES:

LEARNING MATERIALS:
1. Information Sheet
   "Selecting Mercury Marine and OMC Service Manuals and Service Bulletins"
   (Master copy included in this guide.)
2. Sets of Mercury Marine and OMC service manuals and service bulletins.

EQUIPMENT:
(none used)

AUDIO VISUAL MATERIALS:
(none used)

MODULE 04.02

SERVICE MANUALS AND BULLETINS INFORMATION SHEET

Selecting Mercury Marine and OMC Service Manuals and Bulletins

OMC Outboard Service Manuals

In order to select an OMC Service Manual you must know the model and year of the motor you are working on. Once you have determined the model and year selecting the correct manual is easy. The manuals have the engine year and model printed on them.

Once you have located the correct service manual you can go to the manual's index or table of contents to find the section which contains the information that you need. The table of contents in OMC service manuals is located at the front of each manual just inside the front cover.

The OMC service manuals for model years up to and including 1981 are organized into the following sections:

Table of Contents
Section 1 - Introduction
Section 2 - General Service Info
Section 3 - Fuel System
Section 4 - Ignition System
Section 5 - Powerhead
Section 6 - Lower Unit
Section 7 - Manual Starter (lower hp manuals)
Section 7 - Electrical System (higher hp manuals)
Section 8 - Manual Starter (lower hp manuals)
Section 8 - Remote Control (higher hp manuals)
Section 9 - Power trim and Tilt

The OMC service manuals from 1982 and on are organized into the following sections:

Table of Contents
Section 1 - General Information
Section 2 - Fuel System
Section 3 - Ignition System
Section 4 - Powerhead
Section 5 - Midsection
Section 6 - Gearcase
Section 7 - Manual Starter (lower hp)
Section 7 - Electrical System (higher hp)
Section 8 - Electrical System (lower hp)

Section 8 - Remote Control (higher hp)
Section 9 - Remote Control (lower hp)
Section 9 - Power Trim and Tilt (higher hp)
Section 10 - Power Trim and Tilt (lower hp)
Section 10 - Power Steering (higher hp)

OMC has been quite consistent in organizing their service manuals. As you gain experience using them is quite possible that you will no longer need the index or table of contents. You will go directly to the required section.

OMC Service Bulletins

The following information was taken directly from OMC Service Letter 2, July 1980, Titled "New OMC Bulletin Format - How To Handle and Use Bulletins".

How To Use Service Bulletins

Proper Handling of Service Information

1. *When Service mailings are received in the service only envelope they should be delivered unopened to the service department.*
2. *All service personnel should read and initial the service information.*
3. *The information should then be added to the index and filed in the service bulletin binder.*
4. *We have found that it is easier and more convenient to put the latest service bulletins, service letters and service promotions bulletins on top under their index.*
5. *All service bulletins, service letters, and service promotion bulletins are assigned in numerical order so it can be quickly determined when any are missing.*
6. *Keep a second binder for all non-current bulletins so that information can be retained for trouble shooting earlier marine products.*

When To Use Bulletins and Other Service Information

1. *When an engine is being serviced use standard diagnostic procedures first. (Service manual, Troubleshooting guide, test equipment, etc.)*

2. *If a thorough test does not disclose the problem, check the section of the service bulletin index that applies to the area of the engine.*

Conscientious use of service bulletins and other service information will eliminate costly comebacks due to improper or incomplete repairs. The net result is profitable service and satisfied customers.

The above procedures form the suggested way of using OMC Service Bulletins and other information. If the dealer for whom your are working chooses to use another system be sure to learn it and use it. However, taking the time to read and familiarize yourself with the service bulletins and the information they contain will certainly help you to do a better job.

OMC outboard Service Bulletins are usually Put into a binder labeled "Service Information" and arranged into the following categories:

Fuel Systems & Lubrication
Ignition & Electrical
Powerhead & Starter
Lower Unit & Propeller
Controls & Engine Mounting
Tools & Accessories
Miscellaneous

Also found in the "Service Information" binder are the OMC Service Letters, Service Promotion Bulletins, and a section called "Performance Tips"

Mercury Marine Service Manuals

Mercury Marine service manuals are selected by model and serial number. The model names and serial number ranges of the engines covered in the manual will be printed on its front cover. Once you have located the correct service manual you must go to the manual's index to find the number of the page which has the service information or specifications that you seek.

The Mercury Service manuals are usually arranged into the following sections, (the index is usually found inside the cover page of Section 1) :

Service Manual Outline
Section 1 - General Information & Specifications
Section 2 - Electrical & Ignition
Section 3 - Fuel System & Carburetion
Section 4 - Powerhead
Section 5 - Lower Unit

Section 6 - Power Trim or Rewind Starter
Section 7 - Outboard Installation, Engine Attachments, Rewind Starter
Section 8 - Oil Injection System, Autoblend
Section 9 - Electronic Fuel Injection

Not all Mercury service manuals will have all of these sections. For example, the manual for the 18, 20, 25 hp series of motors will not include Section 9 - Fuel Injection and the manual on the 3.4 litre - 300hp model will not have a section on rewind starters. Generally, all manuals will have Sections 1 through 5 with the same names as listed above.

Mercury Marine Service Bulletins

Mercury Marine Service Bulletins should be used in the same way as OMC Service Bulletins. Follow regular troubleshooting procedures and your service manual. Go to the service bulletins when normal procedures yield no results.

Mercury and Mariner Outboard Service Bulletins are identified by having either the words "Mercury Outboard" or Mariner Outboard" printed across the top of bulletin. Both are numbered using the year of issue and a sequence number. The Mercury service bulletin 84-10 would be the tenth bulletin for the 1984. The Mariner service bulletin 84-10 would be the tenth bulletin for the year 1984 and would not necessarily contain the same information as Mercury bulletin 84-10.

Mercury and Mariner service bulletins are generally arranged in the following categories:

Accessories/Control Linkage
Powerhead/Cooling
Electrical/Ignition
Fuel System/Carburetor
Power trim/Hydraulics
Lower Unit/Clamp & Swivel Bracket
Installation/Performance
Specifications/Propellers
Rewind/Cowls
Tools/Service aids

NAME________________________ STUDENT NO.________________________

04.02

PERFORMANCE CHECKLIST

MODULE : Selecting Service Manuals and Bulletins

COMPETENCY: Select service manuals and bulletins according to task requirements.

1. ☐ Located and recorded Mercury model and serial number
2. ☐ Found Mercury service manual using model and S/N
3. ☐ Found Mercury service bulletins according to task
4. ☐ Located OMC and recorded OMC model number
5. ☐ Identified OMC model year
6. ☐ Found OMC service manual using model and model year
7. ☐ Found OMC service bulletins according to task
8. ☐
9. ☐
10. ☐
11. ☐
12. ☐
13. ☐
14. ☐
15. ☐

COMPETENCY ACHIEVED? ☐ **YES** ☐ **NO**

EXPLANATION:

MODULE 04.03

FINDING PARTS AND PRICE INFORMATION INSTRUCTOR GUIDE

COMPETENCY:

1. Look up Mercury and OMC outboard engine parts and accessories in:
    Mercury printed parts catalog
    Mercury Microcatalog Parts System
    OMC printed parts catalog
    OMC microfiche parts catalog

2. Verify Mercury part numbers.
3. Verify OMC part numbers.

INSTRUCTIONAL OBJECTIVES:

The student will be able to:

1. Make parts lists.
2. Interpret the codes found in Mercury Marine and OMC parts catalogs and price books.
3. Use Mercury Marine and OMC parts catalogs to look up outboard engine and accessory part numbers.
4. Use the Mercury Marine and OMC microfiche parts catalogs to look up outboard engine and accessory part numbers.
5. Use Mercury and OMC price books to verify part numbers.
6. Use Mercury and OMC price books to look up price information.

LEARNING ACTIVITIES:

1. Participate in class lectures and discussions.
   (Objectives 1 - 6)
2. Read and study the information sheet "Looking Up Parts and Price Information"
   (Objectives 1 - 6)

EVALUATION/CHECK-OUT:

The instructor will evaluate your ability to make parts lists, look up and verify part numbers, and look up price information as you work on projects in the shop. Your performance will be recorded on the Finding Parts and Price Information performance checklist.

RESOURCES:

LEARNING MATERIALS:

1. Information Sheet
   "Looking Up Parts and Price Information"
   (Master copy included in this guide)
   Adapted from Learning Guides developed for the Marine Mechanics program at Seminole Community College in 1984.

MODULE 04.03

Seminole Community College
Sanford, FL 32771

EQUIPMENT:

1. Mercury Marine: parts catalogs
    - microcatalog index
    - parts microfiche set
    - price book
2. OMC : parts catalogs
    - parts microfiche
    - price book
3. Microfiche viewer

AUDIO VISUAL MATERIALS:

(none used)

FINDING PARTS AND PRICE INFORMATION SHEET

In order to service engines you must be able to determine engine model and year, be able to select repair part numbers from catalogs, verify part numbers, and look up part price information. This information sheet will help you learn how to select parts catalogs and look up part numbers.

Parts Lists

A parts list is a document that is used to communicate information about repair parts and accessories. A parts list is usually a list of the billable materials needed to complete a repair job on an engine or a boat and is prepared by the technician. A parts list will always appear in some form on service orders and customer's invoices. The parts list can also be used as a purchase order by the parts department when ordering from parts manufacturers or when ordering by telephone.

Parts information must be communicated accurately. Specifying unclear or incorrect part numbers will cause the wrong parts to be delivered from stock or from the manufacturer. In either case the mistake will cost money in the form of work delays, extra labor for restocking, or unnecessary parts purchases. These extra costs will directly affect your earning potential.

In order to communicate parts information clearly and effectively the list must be organized so that it can be easily understood. The parts list must also provide information that will help to catch errors. A parts list which is well organized and which will help prevent errors is arranged into columns of information and will look something like the form shown below.

PARTS LIST

Item	Qty	Part No.	Description	Price	

The "Item" column is used to number the individual items in the list when the list contains several parts. The item numbers are not already filled so that you can use more than one line to fill in information about the same item.

The "Qty" is an abbreviation for the word "Quantity". This column is used to specify how many or how much of this item is needed. It is important to specify units along with quantities. Units clarify the quantities specified. They are words like "each" (ea.), "feet" (ft.), "meters" (M), "millimeters" (mm), "pounds" (lb.), "kilograms" (kg), "quarts" (qt.), "gallons" (gal.), "dozen" (dz.), "gross" (gr.), "cubic feet" (cu.ft.). Units need to be specified in order to assure that everyone who reads the parts list understands exactly what the quantity is. Example: you specify a quantity of 1 on a parts list which will be sent to a manufacturer of screws. Is it 1 ea., 1 dz., 1 gr., 1 lb., or 1 kg? All are units common to screw manufacturers. You certainly don't want 1gr., (which is 144 ea.), when you only require 1 ea.

The "Part No." column is obviously the place where the part number is filled in. Take extra care to make sure that the part number is legible. Be sure to verify all part numbers using the price book.

The "Description" column is used to briefly describe what the part number is specifying. Descriptions look like: "Oversize piston ring", "Water pump repair kit", "Propeller", "Gearcase fill screw". Really, the only information needed to specify a particular part is its number. The "Description" information is provided to give those persons using the list the opportunity to catch mistakes. You will need to know what each item is when you are verifying your own parts lists. If you specify a part number that is incorrect or unclear the person filling your order or pulling the part from stock can see that the item specified by the part number does not match the description. At that point they can make an effort to contact you and ask for an explanation.

The "Price" column can contain different kinds of prices depending on what the parts list is being used for. If the parts list is for a customer job then "Price" is really the cost to the customer or "List price". If the parts list is to be used to order parts for stock then "Price" is really the amount the dealer pays for the parts or "Cost". It is very important not to confuse these two "Prices". In most cases you will find that dealers use separate parts lists forms for customer invoices and parts ordering. Separate forms will prevent confusion.

A filled-in parts list will look something like the one shown on the next page.

PARTS LIST					
Item	Qty	Part No.	Description	Price	
1	6 ea.	1/4x20SC	1/4 - 20 SCREW $0.25ea	1	50
2	1 ea.	UL77V	SPARK PLUG	2	75
3	1 ea.	497884	WATER PUMP REPAIR KIT WITH		
			STAINLESS LINER	56	98
4	2 dz.	TM44A2	CABLE TIES $0.15ea	3	60

The parts lists that you will make up while performing repairs are generally written on the service order for the job. To help keep the service order neat you should develop your repair parts list on a separate form or worksheet. If you do not have a pre-printed parts list worksheet you can use a blank piece of paper to make your own form. You will record the quantities, part numbers, and descriptions of all the parts that you use on the worksheet and then transfer the information to the service order or service invoice when the job is complete. The original service order can be kept neat and clean to present the proper image to your customers.

USING PRINTED PARTS CATALOGS

The trend in the marine business is to use microfiche parts catalogs. There are, however, a number of dealerships which still use the printed catalogs or which have printed catalogs for older engines and have updated to microfiche for later models. Some people will argue the merits of one system over the other but it really is a matter of personal preference. As a student technician you need to become familiar with both.

Mercury Marine Printed Parts Catalogs

To look up parts in the Mercury printed catalog you must first determine the engine's model number and serial number. Write down the model number and serial number at the top of you parts list. The parts catalogs will have divider tabs indexed with model numbers and serial number ranges. Find the volume containing your parts catalog volume by comparing your model and serial numbers to the ones listed on the catalog tabs. It is possible that more than one volume will contain parts listings for your model so be sure to check carefully.

When you have located the correct parts catalog volume open it to the index page for your model motor. (An example of a Mercury parts catalog index is shown in Figure 1 included with this information sheet.) On the index or following page there may or may not be a list of serial number groups like the page shown in Figure 1. If there is a list of serial number groups you must determine which group or groups will contain your serial number. Record the identification numbers of the serial groups containing your serial number on the parts list. You will need to refer to them later.

The index will list the various headings or sub-assemblies of an engine, e.g., bottom cowl, stop switch assembly, carburetor assembly, etc. Locate the heading or sub-assembly which contains the part that you need to look up and get its page number. Go to that page to begin looking for your part. Also listed on the index page are the meanings of any special symbols or codes used in the catalog parts lists. For example, a small dark square printed before a part number indicates that the part is included in the contents of a gasket set.

Parts in the parts catalog are shown in pictures of sub-assemblies called exploded views. The exploded view shows how the parts are located in the sub-assembly. The exploded view is usually on the left hand page and the list of part numbers and names is usually on the right hand page. Each part shown in the exploded diagram will have a line pointing to it which is labeled with a number. This number is called a reference number. This reference number is the number by which you can locate the part number and name in the parts list on the right hand page. (A typical parts list is shown in Figure 2.) Since the parts list is numbered you may find your part by looking for its reference number in the parts list.

After you have located the reference number of your part in the parts list you may discover that the reference number is listed more than once and has a different part number each time. This is because that reference number is a part that falls into more than one serial number group and each serial number group uses a different part. You can select the correct part number by matching the serial group number for your engine with one of the serial number groups listed next to the part numbers.

Once you have located the correct part number you will write the part number on your parts list. The Mercury part number prefix is a letter and a dash, e.g. "A-", or "C-". You do not need to write down this prefix. In addition to the part number you should also write the part description on you parts list. Copy the description given in the parts catalog. You will also need to specify the quantity. The quantity listed in the parts catalog is the how many of that part number are required per assembly. Most of the time your quantity will be the same as the one in the catalog but the actual quantity you put down depends on the repair job. If you see an "AR" in the quantity column it means that the quantity is "As Required".

You must always remember to handle your parts catalogs with clean hands and great care. If you find that a page has been ripped out of the catalog take the time to repair it. If you cannot read the catalog because of smudge marks or the required page is missing you will be unable to complete jobs and your income will be affected.

Using the Mercury Marine Price Book

After you have completed your parts list you will need to verify the part numbers and look up prices for each item in the list. To do this you will need a "price book". Mercury Marine calls their price book the "Master Price Lists" and the information in it the "Suggested Price List and Part History Record".

Inside the front cover, (p. 2), of the Master Price Lists book you will find information on ordering various quantities of oil and a list of part classification codes. These are the codes that come after the letter prefix of the part number, e.g., in A-10-177621B14 the classification code is 10. The part classification codes tell you what type of part a particular number belongs to. Examples are: 10- is screws and bolts; 91- is tools and equipment; 700- is pistons. The classification code can be an easy way of verifying a part number. If your part is a propeller and the part number you have written down has a classification code of 91, (which is tools), you know that you have made a mistake.

MODULE 04.03

On page 3 of the Master Price Lists you will find information describing how to use the price list. Everything that you need to know about the price book and its codes is found there. You should refer to it anytime you find something in the price list that is unclear or that you don't understand.

To verify a part number all you have to do is find it in the Master Price Lists with valid price information and a description that matches. If you find another part number in the Description column of your part number, your original number has been "superceded" or replaced by that part number. You must now look up the new number and it also may have been replaced or superceded. Continue to look up the new part numbers until you end up at a valid one. This process can continue for several part numbers. It will be easy to lose track of the numbers so you should use a piece of scratch paper to write each number down. You can use the list of numbers to help back-track if you get lost in the price book or come up with the wrong part. DO NOT use the parts list as scratch paper.

If you find "N.L.A" int the DISP column of your part number your part is No Longer Available. Advise your service manager or supervisor of the unavailable parts and ask for further instructions.

The prices listed in the Master Price Lists are all suggested retail or list prices. This is the price that you write down on your list to give to the customer. If you need to know "dealer cost" for a part you must locate the discount code for the part,look up the discount code in the front of the Master Price Lists, and apply it to the given list price.

Outboard Marine Corporation Printed Parts Catalogs

In order to locate the parts catalog for an OMC engine you must know its horsepower, model number, and model year. Write down this information at the top of you parts list before you go to the parts catalogs.

Outboard Marine Corporation has printed parts catalogs for each individual model and year of an engine. The year, model number, and horsepower are clearly marked on the cover of the parts catalogs. Select the appropriate parts catalog by matching your year, model, and horsepower with the one printed on the catalog.

OMC printed parts catalogs do not have an index listing the page numbers of the various sub-assemblies for your engine. Instead, OMC has arranged the sub-assemblies in the catalog according to how they are found on the engine from its top to its bottom. The flywheel would be located in the beginning of the catalog. A crankshaft will be found somewhere near the middle and the gearcase would be located near the end. Finding the exploded view of a sub-assembly in the catalog is accomplished by knowing where on the engine you part is located. The exploded views in OMC parts catalogs are all on left hand pages. Their accompanying parts listings are on right hand pages.

To find a part number, find the part in the exploded view and note its reference number. Next go to the parts listing and find the reference number. The reference numbers are all listed in order down the left hand side of the parts listing. After locating the reference number in the parts listing record the part number and description on your parts list. Also record the quantity you require. This may or may not be the same as the "quantity per assembly" listed in the catalog. The actual quantity required depends on the individual job.

Using the OMC Price Book

The OMC price book is formally called the "Master Parts Price Book". It is used to verify part numbers and look up price information in the same way as the Mercury Marine Master Price Lists.

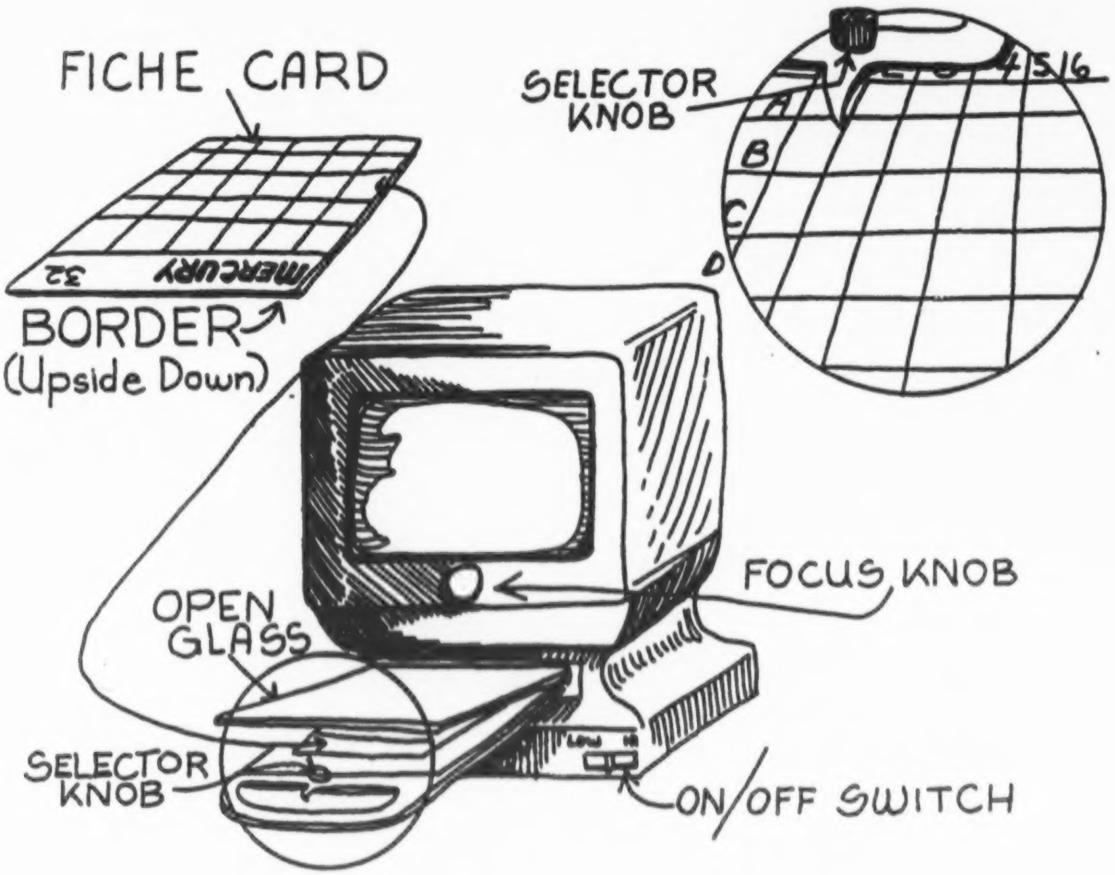
The page just inside the front cover of the Master Parts Price Book contains information about how to use the book and about the codes which can be found there.

You may identify a superceded part number in the OMC Master Parts Price Book by finding a new part number in the PRICE column for the part. You must look up this new number which may also be superceded. Continue to follow the part numbers until you arrive at a valid number.

MODULE 04.03

MICROFICHE CARDS AND VIEWERS

A microfiche, (pronounced microfish), is a piece of film similar to 35mm slide film, except that it is 5-3/4" by 4-1/4" in size. A microfiche is used to store photographically reduced pictures of documents. One 5-3/4" by 4-1/4" microfiche card can hold ninety eight images of standard 8-1/2" by 11" paper. The images on the microfiche are arranged in rows and columns so that any individual page may be located on by using its row and column positions. The rows are usually given the letters A to G and the columns are usually given the numbers 1 to 14. The microfiche position A1 is the first position, (top left corner), on the microfiche and the position G14 is the last position, (bottom right corner). Position A1 on a microfiche usually contains the index to rest of the microfiche. This is an important fact to remember when using microfiche parts catalogs.


FICHE CARD
MERCURY
32
BORDER
(Upside Down)
SELECTOR KNOB
4
5
6
A
B
C
D
FOCUS KNOB
OPEN GLASS
SELECTOR KNOB
LOW
HI
ON/OFF SWITCH

The documents on the microfiche are so small that a type of projector must be used to see them. This projector is called a microfiche viewer. In order to view a microfiche you must put it into the microfiche viewer. As shown in Figure 3, pull out, (toward you, all the way), the part of the machine which is called the microfiche carrier. It is usually tucked under the screen all or part of the way and has the selector knob attached to it. When you have pulled the carrier out all the way you will notice that the piece of glass laying on the carrier has opened to accept the microfiche. Hold the microfiche card by the top border and place it in the carrier bottom edge first.

Turn the viewer power switch to the ON position. Most viewers have HIGH and LOW positions on this switch to allow you to vary the brightness of the screen. Choose whichever setting you like best.

Move the microfiche carrier using the selector knob until the pointer is at position A1 on the grid printed on the viewer. You may have to move the carrier slightly to center microfiche page A1 on the screen. If the image on the viewer screen is not clear use the focus knob to sharpen the image. Not all microfiche cards are top quality so you may have to settle for the best you can do.

The microfiche file is the box where the microfiche cards are kept. It is usually made of smoke colored plastic and has dividers, (which may or may not be labeled), to help keep the file organized. In the front of the file you will find a brightly colored plastic card which has the words "FICHE IN USE" printed on it. This card is to be inserted in the file in place of any card that you take out. When you are through using the microfiche you will put it back in the file in place of the "FICHE IN USE CARD" and return the "FICHE IN USE" card to the front of the file.

The following is the set of rules to observe when using the microfiche viewer and microfiche card file:

1. Wash your hands thoroughly before going near the viewer or card file. Grease and solvents will dissolve the printing on the microfiche cards.
2. Never carry parts of any kind to the microfiche area as they probably have solvents, oil, dirt, or grease on them.
3. Do not take more than one microfiche card out of the file at a time.
4. Always use the "FICHE IN USE" card as a place holder when you take a fiche out of the file.
5. Do not leave the microfiche viewer ON with a fiche in it when you leave the area. Put the fiche back in the file

and turn off the viewer.

Advantages of Microfiche Parts Catalogs

Some of the advantages of a microfiche parts catalog system are the following:

1. Its less expensive than printed catalogs.
2. It can be stored in a smaller place.
3. It is easily filed.
4. Parts of it may be easily replaced.
5. It is more durable than the printed catalog.

Many dealerships use microfiche exclusively, printed catalogs exclusively, or combinations of both.

Using the Mercury Marine Microfiche Parts Catalog

The Mercury microfiche parts catalogs contain exactly the same information as the printed catalogs. They are photographs of the printed ones. The procedure for using the microfiche parts catalogs differs from the procedure for the printed catalogs only in the method used to find individual catalogs.

Use the following steps to locate parts in the Mercury microfiche parts catalog:

1. Determine and record the engine's serial number.

2. Go to the Outboard Model Index for the Microcatalog Parts System. This is a blue wall chart which lists model and serial number groups with microfiche card numbers. It starts with the electric outboards at the top and progresses on to the highest horsepowers at the bottom. Look up the number of the required microfiche card by finding your model and serial number on the Outboard Model Index and then reading the microfiche card number.

3. Mercury microfiche cards are stored in the file in numerical order. Find the card that you need, remove it from the file and replace it with the "FICHE IN USE CARD". Put the fiche in the viewer and turn the viewer on.

4. Since there may be several parts manuals on the same microfiche card you must search the card to find the

one you need. Unfortunately, not all the parts manuals begin at the left hand side of the fiche. Finding the index you need may be tricky. Take care to be sure you know what you are looking at.

5. Having located your parts manual and index use the same procedure that you would use to look up parts in a Mercury printed manual.
6. When finished, refile your microfiche and turn off the viewer.

Using the OMC Microfiche Parts Catalogs

Outboard Marine Corporation microfiche parts catalogs are arranged in the file chronologically according to horsepower from lowest to highest. That means that the parts fiches for older engines will be in the front of the file and the newer one toward the rear. Within the group of fiches for each year the low horsepower catalogs are in front and the high horsepower catalogs are in the rear. To help you identify individual catalogs the model year and horsepower are printed across the top of every fiche.

OMC microfiche parts catalogs are the same in structure as their printed catalogs.

To look up parts using the OMC microfiche parts catalog use the following steps:

1. Locate and record your model number.
2. Determine the model year from the model number.
3. Select the appropriate fiche by using the model year and horsepower.
4. Remove the fiche from the file and replace it with the "FICHE IN USE" card. Place the fiche in the viewer.
5. Locate and record your parts information, (remembering that OMC arranges parts lists from the top of the engine and down).
6. When finished remove the fiche, replace it in the file, and turn off the viewer.

CONTENT INDEX

Page

Content Index 1
Parts Manual - page 1 2
Parts Manual - page 2 3

INDUCTION SYSTEMS

Two - Cycle Engine Principle 4
Direct Charge Cylinder & Power Porting 5
Loop Charge System 6

FUEL SYSTEMS

Break-In Procedure and Fuel Mixture 7
Gasohol in Outboard Motors 8
Anti-Siphon Valves 9
Fuel Pump Operation 10
Mariner Fuel Pumps 11
Mercury 3.5/3.6 Carburetor 12
Mariner Carburetor Start Circuit 13
Mariner Carburetor Idle Circuit 13
Mariner Carburetor Off Idle Circuit 14
Mariner Carburetor Main Circuit 14
Mercury 18/25 Tillotson Carburetor .... 15 - 16
Walbro 18/20/25 Carburetor .... 17 - 19
Carburetor Boost Venturi - Low Speed 20
Carburetor Boost Venturi - High Speed 20
Side Bowl Carburetor - Backdraft System 21
Integral Fuel Pump Carburetor - Low Speed 22
Integral Fuel Pump Carburetor - High Speed 22
Tillotson/Walbro 50 - Backdraft System 23
Tillotson/Walbro Integral Fuel Pump 23
Center Bowl Carburetor - Start System 24
Center Bowl Carburetor - Idle System 24
Center Bowl Carburetor - Off Idle System 25
Center Bowl Carburetor - High Speed System 25
Center Bowl Carburetor - Backdraft System 26
V-6 Carburetor - Low Speed 27
V-6 Carburetor - Off Idle System 27
V-6 Carburetor - High Speed 28
V-6 Carburetor - Backdraft System 28
Enrichener Circuits 29

ELECTRICAL SYSTEMS

Measuring Electricity 30
Wiring Colors 31
Battery .... 32 - 33
Battery Testing 34
Alternator Charging System 36
Cranking Circuit 37
Starter Solenoid 38
Timing Gage 39
Spark Plug - Symbols 40
Spark Plug - Analysis Standard Plug 41
Spark Plug - Analysis Surface Gap 42
Spark Plug - Cross Reference Chart 43
Conventional Ignition System 44
Merc/Mariner Thunderbolt Breakerless 45
Thunderbolt Phase Maker Point Ignition 46
Merc 3.5/3.6 Ignition System 47
Merc 18-25 and Mariner 20-25 (U.S.) Ignition System 48
Merc 20 H.P. Ignition System 49
Merc 402 Ignition System 50
Merc 500 Alternator Driver Ignition 51
ADI Ignition Capacitor Charging Voltage 52
Merc/Mariner V-6 and 3 Cylinder Trigger 53
Merc/Mariner 4-Cylinder Trigger 54
Merc/Mariner 3-Cylinder ADI Ignition 55
Merc/Mariner 4-Cylinder ADI Ignition 56
Merc/Mariner V-6 Models ADI Ignition 57
Idle Sabilizer 58

Page

Mariner 2 H.P. Magneto (Breaker Type) 60
Mariner 3.5 & 5 (air cooled) Magneto (Breaker Type) 61
Mariner 8A - 15A & W - 20 - 28 Magneto (Breaker Type) 62
Mariner 8B - 9.9 - 15C - 25 - 40A & B Bendix Magneto 63
Mariner Bendix Magneto Operation (Flow Chart) 64
Mariner 4 - 5 (Water Cooled) CDI 65
Mariner 4 - 5 Automatic Spark Advance Waveform 66
Mariner 8, 9.9, 15, 25 (Non-U.S.), 30, 40, W48, W55 - C.D.I. 67
Mariner 48, 55 & 60 ("Small Bore") C.D.I. 68
Mariner 60 (Large Bore) CDI Principle of
  Operation .... 69 - 72
DVA - Direct Voltage Adaptor Test Manual .... 73 - 74
Testing - Troubleshooting CDI Ignition .... 75 - 78
Variable Speed Pulser (Test Procedure) .... 80 - 83

LOWER UNITS

Pinion Gear Depth 84
Water Pumps Theory and Failure 85

CORROSION

Corrosion Troubleshooting .... 86, 87 - 88
Galvanic Corrosion Reference Electrode .... 89 - 90

POWERHEAD

Cylinder Surface Finish 92
Micrometer Readings (Cylinder Bore) 93
Crankcase Cover/Cylinder Block Sealing Procedure 94
Detonation/Preignition Causes 95
Connecting Rod and Piston Inspection 96
Caged Type Roller Bearings 97
Crank and Rod Wear .... [illegible]8
Reed Stop Measurement 99
Inside and Outside Diameters .... 100 - 101
I-L Old Type Bleed System 102
I-L New Type Bleed System 103
V-6 Bleed System 104
V-6 Water Flow (Cooling System) 105
Chrome - Plated Cylinder Bore Servicing 106

OIL INJECTION SYSTEM

Oil Injection System Flow — V-6 108
Pump Drive System, Oil Pump — V-6 109

POWER TRIM SYSTEMS

Power Trim - 4 & 6 Cylinder Prestolite .... 110 - 113
Power Trim - V-6 2 Ram Prestolite .... 114 - 119
Power Trim - V-6 Single Ram Oildyne .... 120 - 124
Power Trim - External Mounted Prestolite/Eaton .... 125 - 130

ELECTRIC TROLLING MOTORS

Old Style - DM Model - High & Variable Speed 131
Old Style - RC Model High & Variable Speed 132
New Style - DM & TM Model - Forward Speeds 133
New Style - DM & TM Model - Reverse Speeds 134
New Style - RC Model - All Speeds 135
Thruster Extension Kit 136

PROPELLERS

Propeller Application .... 137 - 139

TUNE-UP SPECIFICATIONS

Mercury Tune-Up Specifications .... [illegible]40
Mariner Tune-Up Specifications .... [illegible]1

SERVICE BULLETIN INDEXES

Mercury Service Bulletin Index .... 142 - 160
Mariner Service Bulletin Index .... 161 - 171
Notes .... 172 - 176

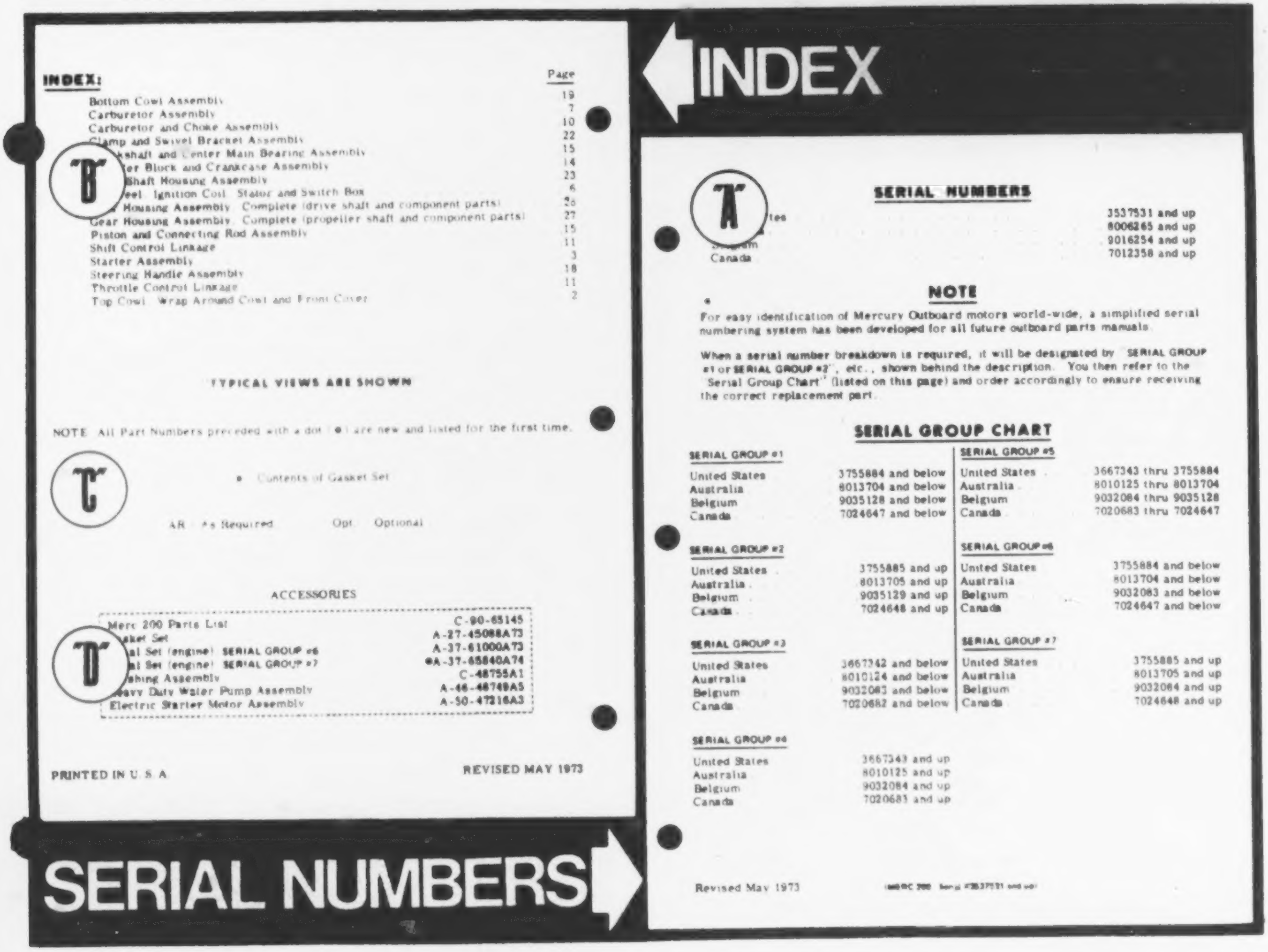
YOUR PARTS MANUAL

FIGURE 1.

Note the printed color tabs on the divider sheets of your Parts Manual and turn to the desired parts list.

Open to the "Index" page and "Serial Numbers" page (immediately following parts list cover), shown below.

- **"A" - Observe serial number to identify proper Merc model from which to select and order parts.**
- **"B" - Index of assemblies.**
- **"C" - Symbols (●, etc), shown throughout parts list, are defined here or on bottom of individual parts list page.**
- **"D" - List of miscellaneous parts not shown elsewhere.**



INDEX:

	Page
Bottom Cowl Assembly	19
Carburetor Assembly	7
Carburetor and Choke Assembly	10
Clamp and Swivel Bracket Assembly	22
kshaft and Center Main Bearing Assembly	15
er Block and Crankcase Assembly	14
Shaft Housing Assembly	23
eel Ignition Coil Stator and Switch Box	6
Housing Assembly Complete (drive shaft and component parts)	26
Gear Housing Assembly Complete (propeller shaft and component parts)	27
Piston and Connecting Rod Assembly	15
Shift Control Linkage	11
Starter Assembly	3
Steering Handle Assembly	18
Throttle Control Linkage	11
Top Cowl Wrap Around Cowl and Front Cover	2

TYPICAL VIEWS ARE SHOWN

NOTE All Part Numbers preceded with a dot (●) are new and listed for the first time.

● Contents of Gasket Set

AR As Required   Opt Optional

ACCESSORIES

Merc 200 Parts List	C-90-65145
sket Set	A-27-45088A73
al Set (engine) SERIAL GROUP #6	A-37-61000A73
al Set (engine) SERIAL GROUP #7	●A-37-65840A74
shing Assembly	C-48755A1
avy Duty Water Pump Assembly	A-46-48749A5
Electric Starter Motor Assembly	A-50-47216A3

PRINTED IN U.S.A.   REVISED MAY 1973

SERIAL NUMBERS

tes	3537531 and up
	8006265 and up
gium	9016254 and up
Canada	7012358 and up

NOTE

For easy identification of Mercury Outboard motors world-wide, a simplified serial numbering system has been developed for all future outboard parts manuals.

When a serial number breakdown is required, it will be designated by "SERIAL GROUP #1 or SERIAL GROUP #2", etc., shown behind the description. You then refer to the "Serial Group Chart" (listed on this page) and order accordingly to ensure receiving the correct replacement part.

SERIAL GROUP CHART

SERIAL GROUP #1

United States	3755884 and below
Australia	8013704 and below
Belgium	9035128 and below
Canada	7024647 and below

SERIAL GROUP #2

United States	3755885 and up
Australia	8013705 and up
Belgium	9035129 and up
Canada	7024648 and up

SERIAL GROUP #3

United States	3667342 and below
Australia	8010124 and below
Belgium	9032083 and below
Canada	7020682 and below

SERIAL GROUP #4

United States	3667343 and up
Australia	8010125 and up
Belgium	9032084 and up
Canada	7020683 and up

SERIAL GROUP #5

United States	3667343 thru 3755884
Australia	8010125 thru 8013704
Belgium	9032084 thru 9035128
Canada	7020683 thru 7024647

SERIAL GROUP #6

United States	3755884 and below
Australia	8013704 and below
Belgium	9032083 and below
Canada	7024647 and below

SERIAL GROUP #7

United States	3755885 and up
Australia	8013705 and up
Belgium	9032084 and up
Canada	7024648 and up

Revised May 1973   (MERC 200 Serial #3537531 and up)

GEAR HOUSING ASSEMBLY, COMPLETE

PART NO.	REF. NO.	DESCRIPTION			Q[illegible].
A-1623-4934A8	-	Gear Housing Assembly, Complete(SHORT SHAFT)	SERIAL GROUP #1	see note below	1
A-1623-4934A7	-	Gear Housing Assembly, Complete(LONG SHAFT)			1
A-1623-5244A5	-	Gear Housing Assembly, Complete(SHORT SHAFT)	SERIAL GROUP #10		1
A-1623-5244A7	-	Gear Housing Assembly, Complete(LONG SHAFT)			1
A-1623-5829A6	-	Gear Housing Assembly, Complete(SHORT SHAFT)	SERIAL GROUP #15		1
A-1623-5829A7	-	Gear Housing Assembly, Complete(LONG SHAFT)			1
A-1623-6048A4	-	Gear Housing Assembly, Complete(MERC 1500XS)	SERIAL GROUP #23		1
A-1623-6053A4	-	Gear Housing Assembly, Complete(MERC 1500 LONG)			1
A-1623-6048A4	-	Gear Housing Assembly, Complete(MERC 1500XS)	SERIAL GROUP #19		1
■A-1623-6053A14	-	Gear Housing Assembly, Complete(MERC 1500 LONG)			1
A-1623-4934A6	1	Gear Housing Assembly - SERIAL GROUP #1			1
A-1623-5244A6	1	Gear Housing Assembly - SERIAL GROUP #10			1
A-1623-5829A8	1	Gear Housing Assembly - SERIAL GROUP #15			1
A-1623-6048A3	1	Gear Housing Assembly(MERC 1500XS)	SERIAL GROUP #13		1
A-1623-6053A5	1	Gear Housing Assembly(MERC 1500 LONG)			1
C-17-46912	2	Dowel Pin, gear housing locating			2
C-16-57921	3	Stud, gear housing to drive shaft housing (4")			1
C-16-57920	4	Stud, gear housing to drive shaft housing (2 1/16")			2
C-16-56297	5	Stud, water pump base and body to gear housing (3 3/8")			1
C-16-30667	6	Stud, water pump base and body to gear housing (3 1/8")			2
C-31-32898	7	Bearing, roller - drive shaft			1
A-45-64388	8	Drive Shaft(SHORT SHAFT)	SERIAL GROUP #8		1
A-45-64389	8	Drive Shaft(LONG SHAFT)			1
A-45-69250	8	Drive Shaft(SHORT SHAFT)	SERIAL GROUP #9		1
A-45-69251	8	Drive Shaft(LONG SHAFT)			1
A-43-68548	9	Gear, pinion - drive shaft			1
C-11-35921	10	Nut, pinion gear to drive shaft			1
C-15-30278A1	11	Shim, drive shaft ball bearing to gear housing (.002-3-5-10)	SERIAL GROUP #8		AR
C-15-30278A1	11	Shim, water pump base to gear housing (.002-3-5-10)			AR
C-30-63326	12	Bearing, ball - drive shaft			1
C-53-30726	13	Ring, retaining - ball bearing			1
C-23-70412	11	Spacer, roller bearing to water pump base	SERIAL GROUP #9		1
C-15-57007A1	11	Shim, roller bearing to water pump base			AR
C-31-69220	12	Roller Bearing, drive shaft			1
□■C-27-32438	14	Gasket, water pump base to gear housing	SERIAL GROUP #8		[illegible]
□■C-25-30224	15	"O" Ring, water pump base			1
▲C-27-33146	14	Gasket, water pump base to gear housing	SERIAL GROUP #9		1
▲C-25-33145	15	"O" Ring, water pump base			1
A-46-48747A1	16	Water Pump Base Assembly - SERIAL GROUP #8			1
A-46-69222A1	16	Water Pump Base Assembly(with flush hole)	SERIAL GROUP #9		1
A-46-73804A1	16	Water Pump Base Assembly(without flush hole)			1
C-26-31489	17	Oil Seal, water pump base			1
C-26-31507	18	Oil Seal, water pump base			1
C-17-35973	19	Dowel Pin, water pump base to water pump body			2
▲□■C-27-32433	20	Gasket, lower - water pump base to face plate			1
C-32435	21	Plate, face - water pump base to water pump body			1
▲□■C-27-32434	22	Gasket, upper - face plate to water pump body			1
A-46-64141A1	23	Water Pump Body Assembly			1
A-48752	24	Insert, water pump body			1
▲□■C-26-38970	26	Seal, rubber - water inlet tube			1
C-47-65960	27	Impeller, water pump			1
C-28-56654	28	Key, impeller drive			1
C-10-30720	29	Screw, water pump body to gear housing (2 1/4")			1
C-13-26992	30	Lockwasher, water pump body screw			1
C-12-29245	31	Washer, water pump body fastening screw and stud			3
C-11-35045	32	Nut, water pump fastening screw			2
C-12-36001	33	Washer, water pump body fastening stud			1
C-11-45592	34	Nut, water pump body fastening stud			1
▲□■C-25-30271	35	Ring, rubber - centrifugal slinger (drive shaft)			1
C-23-29804	36	Sleeve, guide - water inlet tube			1
A-60909	37	Seal, exhaust tube	SERIAL GROUP #1	not part of Gear Housing Assembly, Complete	1
A-60910	38	Plate, support - exhaust tube seal			1
A-37641	37	Seal, exhaust tube	SERIAL GROUP #2		1
A-38051	38	Plate, support - exhaust tube seal			1
A-76062A1	39	Shaft Assembly, shift - lower			1
C-53-29641	40	"E" Ring, retaining - shift shaft			1
▲□■C-25-25439	41	"O" Ring, shift shaft bushing			1
C-23-55419A1	42	Bushing Assembly, shift shaft			1
A-26-24590	43	Oil Seal, shift shaft housing (lower)			1
C-26-31249	43	Oil Seal, shift shaft housing (upper)			1
C-12-31266	44	Washer, rubber - shift shaft bushing			[illegible]
A-39019	45	Spacer, lower - reverse locking	NOT USED WITH FULL POWER TRIM		1
A-39021	46	Cam, reverse locking			1
C-10-28634	47	Screw, grease filler and vent hole - SERIAL GROUP #9			2
C-22-67892	47	Screw, drain (magnetic) - SERIAL GROUP #9 - Quantity is 1			1
C-12-20260	48	Washer, grease filler and vent hole screw			2
C-19-48750	49	Plug, gear housing flushing hole	use when applicable		1
C-12-49221	50	Washer, gear housing flushing hole plug			1

FIGURE 2.

NOTE: The enclosed gear housings include all parts from Reference #1 thru #75 as listed on Pages 39 and 42.

TWO-CYCLE ENGINE PRINCIPLE

FIG. 1
COMPRESSION

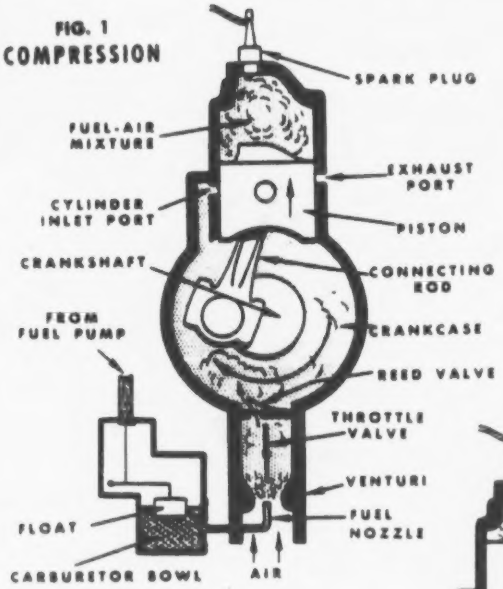

SPARK PLUG
FUEL-AIR MIXTURE
EXHAUST PORT
CYLINDER INLET PORT
PISTON
CRANKSHAFT
CONNECTING ROD
FROM FUEL PUMP
CRANKCASE
REED VALVE
THROTTLE VALVE
VENTURI
FLOAT
FUEL NOZZLE
CARBURETOR BOWL
AIR

FIG. 3
EXHAUST

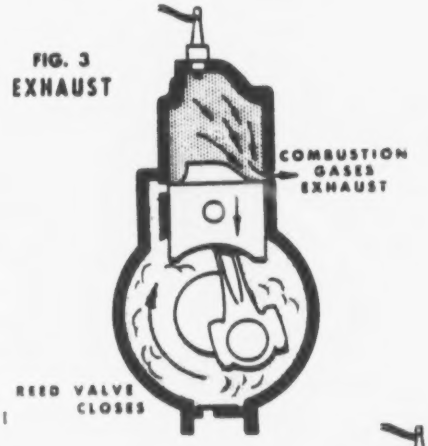

COMBUSTION GASES EXHAUST
REED VALVE CLOSES

FIG. 2
IGNITION

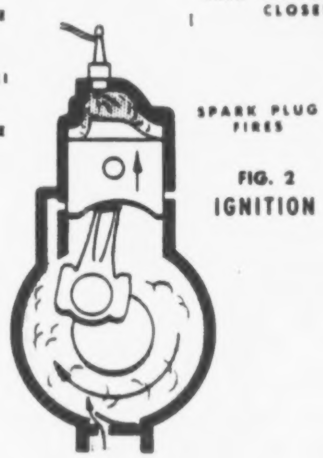
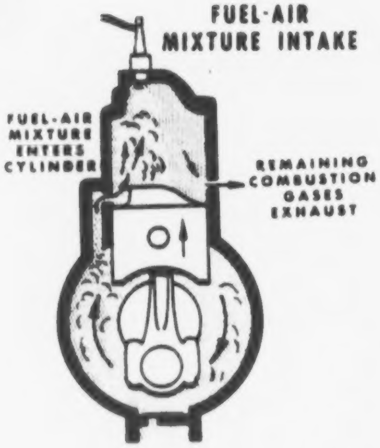

SPARK PLUG FIRES

FIG. 4
FUEL-AIR MIXTURE INTAKE


FUEL-AIR MIXTURE ENTERS CYLINDER
REMAINING COMBUSTION GASES EXHAUST

NOTES:

NAME______________________________ STUDENT NO.______________________________

04.03

PERFORMANCE CHECKLIST

MODULE : FINDING PARTS AND PRICE INFORMATION

COMPETENCY: Use Mercury printed parts catalogs and price book to look up parts, accessories and their prices

1. ☐ Selected appropriate catalog volume
2. ☐ Selected correct serial number group
3. ☐ Selected appropriate sub-assembly
4. ☐ Located and recorded: Volume Number
5. ☐ Quantity
6. ☐ Part Number
7. ☐ Description
8. ☐ Properly stored parts catalogs
9. ☐ Verified part numbers
10. ☐ Found prices for each part number
11. ☐ Followed appropriate cleanliness procedures
12. ☐
13. ☐
14. ☐
15. ☐

COMPETENCY ACHIEVED? ☐ YES ☐ NO

EXPLANATION:

NAME________________________ STUDENT NO.________________________

04.03

PERFORMANCE CHECKLIST

MODULE : FINDING PARTS AND PRICE INFORMATION

COMPETENCY: Use Mercury Microcatalog Parts System and price book to look up parts, accessories and prices.

1. ☐ Used Outboard Motor Index to select microfiche card
2. ☐ Used microfiche card file place marker
3. ☐ Installed fiche in viewer and focused it
4. ☐ Identified serial number groups
5. ☐ Located and recorded: Part Number
6. ☐ Quantity
7. ☐ Description
8. ☐ Refiled fiche, removed place marker, shut off viewer
9. ☐ Verified part numbers
10. ☐ Found prices for parts
11. ☐ Followed appropriate cleanliness procedures
12. ☐
13. ☐
14. ☐
15. ☐

COMPETENCY ACHIEVED? ☐ YES ☐ NO

EXPLANATION:

NAME______________________________ STUDENT NO.______________________________

04.03

PERFORMANCE CHECKLIST

MODULE : FINDING PARTS AND PRICE INFORMATION

COMPETENCY: Use OMC printed parts catalogs and price book to look up parts, accessories and their prices

1. ☐ Selected appropriate catalog volume
2. ☐ Selected appropriate sub-assembly
3. ☐ Located and recorded: Part Number
4. ☐ Quantity
5. ☐ Description
6. ☐ Properly stored parts catalogs
7. ☐ Verified part numbers
8. ☐ Found prices for parts
9. ☐ Followed appropriate cleanliness procedures
10. ☐
11. ☐
12. ☐
13. ☐
14. ☐
15. ☐

COMPETENCY ACHIEVED? ☐ YES ☐ NO

EXPLANATION:

NAME______________________ STUDENT NO.______________________

04.03

PERFORMANCE CHECKLIST

MODULE : FINDING PARTS AND PRICE INFORMATION

COMPETENCY: Use OMC microfiche parts catalog and price book to look up parts, accessories and prices.

1. ☐ Selected appropriate microfiche card
2. ☐ Used microfiche card file place marker
3. ☐ Installed fiche in viewer and focused it
4. ☐ Located and recorded: Part Number
5. ☐ Quantity
6. ☐ Description
7. ☐ Refiled fiche, removed place marker, shut off viewer
8. ☐ Verified part numbers
9. ☐ Found prices for parts
10. ☐ Followed appropriate cleanliness procedures
11. ☐
12. ☐
13. ☐
14. ☐
15. ☐

COMPETENCY ACHIEVED? ☐ YES ☐ NO

EXPLANATION:

WRITING SERVICE ORDERS **INSTRUCTOR GUIDE**

COMPETENCY:

Record customer and service information accurately on Service Order forms.

INSTRUCTIONAL OBJECTIVES:

The student will be able to:

1. Explain the importance of each of the sections on the Service Order form.
2. Interview customers who are leaving their boats to be serviced and record check-in information on Service Order forms.
3. Record service information on Service Order forms.
4. Record parts information on Service Order forms.

LEARNING ACTIVITIES:

1. Participate in class lectures and discussions. (Objectives 1 - 4)
2. Complete the Service Orders worksheet. (Objectives 1 - 4)
3. Practice writing Service Orders by using them to check customers in as they leave their boat, to record the work that you have done to boats in the shop, and to record the parts you have used in completing repair to boats and motors. (Objectives 1 - 4)

EVALUATION/CHECK-OUT:

1. See your instructor to arrange for him/her to observe you write a service order when a customer brings his/her boat in. After you have checked the customer in the instructor will evaluate your performance and record it on the Performance Checklist.

2. The instructor will observe your use of the Service Order while you are working on projects in the shop. Your performance will be recorded on the Performance Checklist.

RESOURCES:

LEARNING MATERIALS:

1. Information Sheet
   "Filling In Service Orders Properly"
   (Master copy included in this guide)

2. Writing Service Orders Worksheet
   (Master copy included in this guide)

3. Copies of blank Service Orders to be use with the Writing Service Orders Worksheet.

EQUIPMENT:
(none required)

AUDIO VISUAL MATERIALS:
(none used)

WRITING SERVICE ORDERS INFORMATION SHEET

Filling Out the Service Order Properly

One of the first and most important parts of getting a service job done is filling out the work/service order. The work/service order is the document used to assist in assigning the job, keeping track of the job, and completing the job. The work/service order can also serve as a parts list, a bill for the services rendered, and a legal contract. Filling out the work/service order neatly, accurately, and completely is important for all of these reasons.

A sample work/service order has been provided along with this Instruction Sheet. It is called Attachment 1. Keep the sample work/service order out where you can see it while reading about each of the sections. This will help you to become familiar with it. Each of the sections has been numbered to help you follow along in your reading. For the rest of this information sheet the work/service order will be called the "service order". Work order and service order are two different names for the same document.

Filling Out and Understanding the Service Order

Why Use Service Orders? The reasons for using service orders are the following :

- Technicians can work from them
- They provide parts list for repairs
- Customer can be billed from them
- Provides a record of work for the purpose of warranty, service record, routine maintenance, and if customer is a regular one old service orders can assist in troubleshooting by providing a trouble history
- Provides a contract for work to be performed

Neatness Counts

Because there are other people besides yourself who will have to read what you write on the service order print neatly. Do not handle the service order when you hands are dirty. Unsightly smudges of oil, grease, and other materials will not only make things unreadable but will reflect poorly on the quality of your work.

Section 1 - Customer Name, Address, Telephone Number

This section is located in the upper left hand corner of the service order immediately to the left of the box containing the words "Seminole Community College". When filling in the customer's name be sure to put down his/her full name, first and last. Having a customer's full name makes it easier to identify him. Service orders written out for several Bobs or Johns can do nothing but create confusion. A second reason to fill in a complete name is because the service order serves as a contract for the services to be performed and may not be legal without the customer's full name. The customer's address is also important to help identify him/her. There are probably lots of people with names like Mary Jones or Robert Smith, but generally only one at a given address. In addition to helping to identify the customer, having the customer's mailing address is important because things like warranty information, boat titles, bills, or keys may have to be mailed to him. Always be sure to ask the customer for his complete address including the zip code. Telephone numbers are important because they provide a way to contact the customer for the authorization of additional work, for notification of job completion, or for bill collection purposes. It is good practice to get the customer's home phone number and work phone number. The customer will generally be at work when important decisions involving his job need to be made. Ask the customer where he works and write it down in the space below the phone numbers line on the service order. Be sure to get the area code if the customer gives you an out of town address or if you know that he does not have the same area code as the shop.

Section 2 - Motor Description Section

This part of the service order is found directly below the "Seminole Community College" box. Take some time to find it on the sample service order and read the labels found inside the box. In the MOTOR MAKE AND MODEL place the motor manufacturer's name and model identification is written. Mercury, OMC, Johnson, Evinrude, Yamaha, and Suzuki are just a few of the motor manufacturer names. The motor model description varies with every manufacturer. You can learn about model numbers in another learning guide. The SERIAL NO. place provides space for the motor's serial number to be written. The serial number is important because it helps identify a particular motor. The serial number will help you keep track of several different motors of the same make and model which may be in the shop at the same time. The serial number is also important because some manufacturers like Mercury catalog their parts in groups by serial number. You need the serial number to look up parts. The YR. place is for writing down the motor's year of manufacture. This information is not always obvious and most of the time will have to be looked up in the manufacturer's year model guide. Year model guides are explained in another learning guide. Knowing the motor's year of manufacture will help identify which service manuals and parts catalogs you will need to work on the motor. The H.P. place is for filling in the motor's horsepower rating. Like the year of manufacture, the horsepower rating of a motor will usually help to identify the necessary service and parts literature required to work on a motor. Motors frequently come into the shop without their boats. When this happens it is good practice to write "motor only" in the Boat description section of the service order. Doing so can help avoid confusion and wasted time.

Section 3 - Boat Description Section

The BOAT MAKE place in this section is for filling the name of the boat manufacturer. The STATE REGISTRATION NO. place is for writing down the boat's registration number which is found on both the port and starboard forward section of the boat. Writing down the registration number is important to help identify a particular boat when several identical boats may be in the shop at the same time. The boat description section of the service order is very important because some jobs require the boat's motor to be removed from the boat. It is easy to forget which motor was rigged on what boat especially in a busy shop with similar boats in for service. Having all the information written down on the service order will help avoid sending a customer out the door with the wrong motor. If a boat comes in for service with no motor it is good practice to write "no motor" in the motor description section of the service order.

Section 4 - Date in and Date out section

Write the date on which you received the boat/motor for service in the DATE IN box. In the DATE OUT box write the date on which the customer took his boat out of the shop. These two dates provide information useful in helping the instructor or service manager at a dealer manage the flow of work in the shop. The DATE IN can also help determine whether or not the boat/motor is in its warranty period and will provide a means of developing a service history for repeat customers.

Section 5 - Written by and Work done by section

The WRITTEN BY box is for the person writing the service order to fill in his/her name or student number. At a dealer this could be an employee code or number. It is important to know who wrote the service order because there may be questions about the information contained in some of the other sections. As an example, the technician assigned to work on the job may want to ask questions about what the customer said was wrong. The WRITTEN BY box was not designed to help catch the persons who make mistakes filling out the service orders. The WORK DONE BY box is obviously filled in by the technician who performs the work with his/her name or number. Having this information is important when questions about the job's status need to be answered. The instructor or service manager at a dealer can use the service orders for incomplete jobs to keep track of who is doing what and to make project assignments. Remember that if you leave your name out of the WORK DONE BY box someone else may get the credit for your excellent work!

Section 6 - Customer Called box

The CUSTOMER CALLED WHEN WORK COMP. box is checked when the customer has been notified that his/her job is complete. This helps remind the person assigned to call the customer to do so and can help the instructor or service manager keep informed of a job's status.

Section 7 - Parts List Section

This section of the service order is for writing down every single part that goes into the customer's boat, motor, or trailer. The time to write the part down is **BEFORE IT IS INSTALLED.** This avoids having to call the customer back because you did not charge him for something that someone left off the service order parts list. It also avoids giving away parts that no one knows the technician installed. The parts list section has four columns : **QTY, PART NUMBER, PART NAME, AMOUNT.** Write how many of each part in the **QTY** column. In the **PART NUMBER** and **PART NAME** columns write down the part number and part name just like you found it in the parts book. In the **AMOUNT** column always write the list price for the part.

Section 8 - The Description of Work Section

This section is really a "work to be done" and a "work done" section. That is, it is a place to write down the type of work that needs to be done and a place to write down the work that was actually done. When writing down the work to be done be sure to interrogate the customer carefully, tactfully, and in great detail about what is wrong. Make sure that what you think the customer is telling you is actually what the customer is telling you. Make the customer define his terms like "awhile", "some", and "a little" so that the technician assigned to the job will have as much information as possible.When writing down the work done and the job involves several procedures list the procedures on the service order. For instance, do not just say "rebuilt motor". Say "removed and disassembled powerhead, replaced crankshaft, pistons, and rod bearings, decarbonized cylinder head, etc.". Do not go overboard with detail but give brief accurate summaries. Remember that the information written down for work done shows the customer what he is paying for and also provides a history of work done for the service record. Always inventory the customer's fuel tanks, batteries, spare fuel lines, etc., and write them down in the description of work section. This will insure that the customer gets everything back.

Section 9 - The Customer Signature Section

The Customer Signature box is in the lower left hand corner of the **DESCRIPTION OF WORK** section. Take some time now to read what is in the customer signature section on the sample service order. When the customer signs the service order he is acknowledging that he has read the information which is in the signature box. The language in the signature box does the following things when the customer acknowledges he has read them by signing the service order:

1) provides a contract for the work to be done
2) relieves the shop of liability for theft or accidental damage to the customer's property
3) authorizes water testing the customer's boat
4) advises the customer that a mechanic's lien has been placed on his boat/motor to secure payment for the repairs. Because of the above four results of having the service order signed the customer signature section is the most important.

MODULE 04.04

Worksheet

NAME________________________________ STUDENT NO.________________

Ask your instructor where to obtain a copy of a blank service order. When you have obtained the blank service order read the information below and fill in the service order. As you are filling the service order recall and review the practical importance of each of the nine sections.

INFORMATION TO BE FILLED IN ON SERVICE ORDER

On March 15, 1986, Ollie Evinrude brought in an 18 foot Skeeter bass boat, registration FL 54123, two tanks in boat, spare fuel line on floor, depth sounder left in case under operator's seat. The motor on the boat is a Johnson GT 150, model number J150TLCR, serial # 4432714. Mr. Evinrude lives in Orlando at 776 Roostertail Trail and his home phone number is 420-6381. His work number is 420-6333 at the U.S. Secret Service.

This is what customer said when he brought boat in, " Yeah, I want one of those new chopper, high performance props put on, and the thing has been sitting up for awhile and I took it out and it would make noises like it was running out of gas when I was trying to get it on. Then it wouldn't even idle right."

The shop did the following things for the customer:

- checked compression
  cyl 1 - 130,
  cyl 2 - 130,
  cyl 3 - 125,
  cyl 4 - 132,
  cyl 5 - 125,
  cyl 6 - 130
- checked for rod bearing end play
  all cylinders OK
- checked gearcase lubricant, OK
- performed general powerhead visual inspection
- installed a high performance propeller
- checked fuel system for presence of water
  found water in carburetor float bowls
  drained fuel tank
  drained fuel line

blew out fuel pump with compressed air
rebuilt carbs
put bottle of fuel dehydrator in tank
refueled with clean fuel

- lake tested boat and motor.

The following parts were used to complete Mr. Evinrude's job: six tuv1357 carburetor rebuild kits at $12.34 each, one 4236 Performance Products 14-1/2x23 chopper prop at $877.32, two 1 1/2 inch 1/4 x 20 stainless steel screws at $0.75 each, one can of DHI99 fuel conditioner. The customer was called on March 25, 1985, and he took the boat home on March 26.

NAME________________________ STUDENT NO.________________________

04.04 **PERFORMANCE CHECKLIST**

MODULE : Writing Service Orders

COMPETENCY: Record customer and service information accurately on service orders

1. ☐ Turn in Service Orders Worksheet.
2. ☐ Interview customer for service check in.
3. ☐ Record check in information on Service Order form.
4. ☐ Record work done information on Service Order form.
5. ☐ Record parts used information on Service Order form.
6. ☐
7. ☐
8. ☐
9. ☐
10. ☐
11. ☐
12. ☐
13. ☐
14. ☐
15. ☐

COMPETENCY ACHIEVED? ☐ **YES** ☐ **NO**

EXPLANATION:

(1) ATTACHMENT 1 (4)

NAME ____________________

ADDRESS ____________________

CITY ____________________ ZIP ____________

PHONE ____________________ WORK ____________

SEMINOLE COMMUNITY COLLEGE

MARINE SERVICE

WRITTEN BY (5)

DATE IN

DATE OUT

CUSTOMER CALLED WHEN WORK COMP. ☐ (6)

MOTOR MAKE AND MODEL (2) SERIAL NO. YR. H.P.

BOAT MAKE (3) STATE REGISTRATION NO.

WORK DONE BY (5)

QTY	PART NUMBER	PART NAME	AMOUNT
	(7)		
	TOTAL	PARTS	

DESCRIPTION OF WORK

(8)

NOT RESPONSIBLE FOR LOSS OR DAMAGE TO BOATS, MOTORS OR ARTICLES LEFT IN BOATS IN CASE OF FIRE, THEFT, ACCIDENT, FREEZING OR ANY OTHER CAUSE BEYOND OUR CONTROL.

I hereby authorize the above repair work to be done along with the necessary material, and hereby grant you and/or your employees permission to operate the vehicle herein described on waterways or elsewhere for the purpose of testing and or inspection.
An express mechanic's lien is hereby acknowledged on above vehicle to secure the amount of repairs thereto.

(9) 198

X

TOTAL TECHNICAL SERVICES	
TOTAL PARTS	
TOTAL LUBRICANT	
TOTAL OUTSIDE REPAIRS	
LAUNCH OR HAULOUT	
DELIVER OR PICK UP	
TAX	
TOTAL AMOUNT	

NAME
ADDRESS
CITY ZIP
PHONE WORK

SEMINOLE COMMUNITY COLLEGE

MARINE SERVICE

WRITTEN BY

DATE IN

DATE OUT

CUSTOMER CALLED WHEN WORK COMP. ☐

MOTOR MAKE AND MODEL SERIAL NO. YR. H.P.

BOAT MAKE STATE REGISTRATION NO.

WORK DONE BY

TY	PART NUMBER	PART NAME	AMOUNT
	TOTAL	PARTS	

DESCRIPTION OF WORK

NOT RESPONSIBLE FOR LOSS OR DAMAGE TO BOATS, MOTORS OR ARTICLES LEFT IN BOATS IN CASE OF FIRE, THEFT, ACCIDENT, FREEZING OR ANY OTHER CAUSE BEYOND OUR CONTROL

I hereby authorize the above repair work to be done along with the necessary material, and hereby grant you and/or your employees permission to operate the vehicle herein described on waterways or elsewhere for the purpose of testing and/or inspection.

An express mechanic's lien is hereby acknowledged on above vehicle to secure the amount of repairs thereto.

X

TOTAL TECHNICAL SERVICES	
TOTAL PARTS	
TOTAL LUBRICANT	
TOTAL OUTSIDE REPAIRS	
LAUNCH OR HAULOUT	
DELIVER OR PICK UP	
TAX	
TOTAL AMOUNT	

UNIT 5 - BOATS, BOAT TOWING, AND BOAT HANDLING

MODULE 05.01

IDENTIFYING BOAT HULL TYPES **INSTRUCTOR GUIDE**

COMPETENCY:

1. Recognize planing and displacement hulls.
2. Identify various types of planing boat hulls.
3. Name boat hull parts.

INSTRUCTIONAL OBJECTIVES:

The student will be able to:

1. Identify displacement hull boats.
2. Identify planing hull boats.
3. Identify types of planing hulls.
4. Explain the performance characteristics of both planing hull and non-planing hull boats.
5. Label the parts of planing hull and displacement hull boats.
6. Explain the terms freeboard, draft, and deadrise.
7. Locate the port and starboard sides of a boat.
8. Describe the relative positions: forward; aft; abeam; ahead; astern; outboard; and inboard in terms of their location on a boat.
9. Identify the two major types of planing hull defects and describe their effects on boat performance.
10. Identify the materials used to construct fiberglass boats.
11. Differentiate hand laid and chopper gun constructed fiberglass boat parts.
12. Describe the steps in the female or cavity mold process of constructing fiberglass boats.

LEARNING ACTIVITIES:

1. Participate in class lectures and discussions. (Objectives 1 - 12)
2. Read chapter 1 in USCG "Boating Skills and Seamanship." (Objectives 1, 2, 4 - 8)
3. Read pages 32 and 33 in Mercury Marine's "Everything You Need To Know About Propellers". (Objectives 3, 9)
4. Read chapters 3 and 4 in "The Performance Boat Bible". (Objectives 9 - 12)
5. Read chapters 3 and 4 in "The Fiberglass Boat Handbook" (Objectives 1 - 12)
6. Write in definitions for the terms on the "Boat Hull Terms Worksheet". (Objectives 1 - 12)
7. Examine the boat hull assigned to you by the instructor. Note all of the hull characteristics. Note what you think the performance characteristics of the boat would be. Record your notes on the "Hull

haracteristics Worksheet". Discuss your notes with the instructor and the class.
(Objectives 1 - 10)

EVALUATION/CHECK-OUT:

1. Turn in your Terms Worksheet.
2. Report on your assigned hull to the class.
3. Turn in your "Hull Characteristics Worksheet".
4. Take the Boat Hulls multiple choice test and score 70% or better.

RESOURCES:

LEARNING MATERIALS:

1. Worksheet
   "Boat Hull Terms"
   (master copy included in this guide).

2. Worksheet
   "Hull Characteristics"
   (master copy included in this guide).

3. Boat Hulls multiple choice test
   (master copy included in this guide).

4. Reference
   Individual or library copies of "Everything You Need To Know About Propellers.", Third Edition, Mercury Marine part number 90-86144.

5. Reference
   Individual or library copies of "Boating Skills and Seamanship", Tenth Edition, First Printing
   United States Coast Guard Auxiliary
   Coast Guard Auxiliary National Board, Inc.
   Washington, DC.
   Library of Congress number 74-164-688.
   ISBN 0-930028-03-1.

6. Reference
   Library copies of "The Performance Boat Bible", by Earl Bentz and Don Wirth, (c) 1983 by Earl Bentz and Don Wirth. Published by B&W Publications, P.O.Box 40405, Nashville, TN, 37204.

7. Reference
   "The Fiberglass Boat Handbook", by Jack Wiley
   (c) 1987 by TAB Books Inc.
   P.O. Box 40
   Blue Ridge Summit, PA 17214

ISBN 0-8306-0399-9

8. Reference
"Modern Boatbuilding Materials and Methods"
Steve Sleight, (c) 1985 Steve Sleight
Published by International Marine Publishing Co.
21 Elm St.
Camden, Maine 04842.
(207) 236-4342.
Library of Congress no. 85-04561.
ISBN 087742-210-9.

EQUIPMENT:
(none required)

AUDIO VISUAL MATERIALS:
(none used)

MODULE 05.01

NAME________________________________ STUDENT NO.________________

Boat Hull Terms Worksheet

---

1. bow -

2. stern -

3. transom -

4. keel -

5. chine -

6. strake -

7. stringer -

8. bulkhead -

9. splash well -

10. bilge -

11. waterline -

12. forward -

13. aft -

14. abeam -

15. ahead -

16. astern -

17. outboard -

18. inboard -

19. hook -

20. rocker -

21. porpoising -

22. plowing -

23. cavity mold -

24. gel coat -

25. plug -

MODULE 05.01

NAME________________________________ STUDENT NO.________________

HULL CHARACTERISTICS WORKSHEET

Manufacturer-

Boat Length -

Beam -

Hull Type -

Deadrise -

Chine Type -

Freeboard -

Construction-

How will this boat perform?

What would be the best use for this boat?

MODULE 05.01

IDENTIFYING HULL TYPES Multiple Choice Test

NAME________________________________ STUDENT NO.__________________

1. A planing hull is designed to
   - a) push the water aside as it moves through it.
   - b) ride on top of the water.
   - c) act like an airfoil.
   - d) have more freeboard than a displacement hull.

2. A displacement hull is designed to
   - a) push the water aside as it moves through it.
   - b) ride on top of the water.
   - c) act like an airfoil.
   - d) have more freeboard than a planing hull.

3. Freeboard is the
   - a) depth of a sailboat keel.
   - b) height of the boat's transom.
   - c) distance from the waterline to the top of the gunnels.
   - d) depth of water a loaded boat hull will float in without grounding.

4. Draft is the
   - a) depth of a sailboat keel.
   - b) height of the boat's transom.
   - c) distance from the waterline to the top of the gunnels.
   - d) depth of water a loaded boat hull will float in without grounding.

5. Deadrise angle is the angle
   - a) of hull rise from the keel to the chine in a V hull boat.
   - b) that the transom makes with the boat.
   - c) that the bow makes with the center line.

d) of roll that a hull can make before taking on water.

6. The port side of a boat is the _______ side of the boat when facing the stern.

a) right hand
b) left hand

7. The starboard side of the boat is the ________ side of the boat when facing the transom.

a) right hand
b) left hand

8. The port side of the boat is the ________ side of the boat when facing forward.

a) right hand
b) left hand

9. The starboard side of the boat is the ________ side of the boat when facing the bow.

a) right hand
b) left hand

10. A hook in the hull of a planing boat will cause

a) leaks.
b) steering problems.
c) porpoising.
d) a poorly designed hull to stop porpoising.

11. A rocker in the hull of a planing boat will cause

a) leaks.
b) steering problems.
c) porpoising.
d) a poorly designed hull to stop porpoising.

12. Gel coat is

a) used to seal crankcase halves during a rebuild.

b) usually used to seal the inside of a molded boat.
c) the wetting compound for glass mat.
d) usually the first thing put in the mold.

13. FRP

a) Final Resin Patch
b) Fiberglass Resin, Pure
c) Fiber Reinforced Plastic
d) Final Resin Ply

14. The resin most commonly used in boatbuilding is

a) a two part polyester plastic.
b) a two part epoxy.
c) C6 Green.
d) C6 Blue.

15. A chopper gun is used to

a) chop up fiberglass mat, combine it with resin, and shoot it into molds.
b) aid in the release of the hull from the mold.
c) remove molding flanges from molded parts.
d) cut hatchways in raised deck boats.

MODULE 05.01

IDENTIFYING HULL TYPES Multiple Choice Test

ANSWER KEY

1. B
2. A
3. C
4. D
5. A
6. A
7. B
8. B
9. A
10. D
11. C
12. D
13. C
14. A
15. A

NAME________________________ **STUDENT NO.**________________________

05.01 **PERFORMANCE CHECKLIST**

MODULE : Identifying Boat Hull Types

COMPETENCY: 1. Recognize planing and displacement hulls.
2. Identify various planing hull types.
3. Name boat hull parts.

1. ☐ Turn in your Terms Worksheet.
2. ☐ Turn in your "Hull Characteristics Worksheet".
3. ☐ Report on your assigned hull.
4. ☐ Take test.
5. ☐ Score.
6. ☐
7. ☐
8. ☐
9. ☐
10. ☐
11. ☐
12. ☐
13. ☐
14. ☐
15. ☐

COMPETENCY ACHIEVED? ☐ YES ☐ NO

EXPLANATION:

MODULE 05.02

IDENTIFYING PROPULSION SYSTEMS **INSTRUCTOR GUIDE**

COMPETENCY:
Recognize and name various types of marine propulsion systems.

INSTRUCTIONAL OBJECTIVES:

The student will be able to:
1. Identify inboard/outboard drive systems, inboard drive systems, surface drive systems, jet drive systems, and Sea Drive systems.
2. State the names of three major outboard manufacturers found in the United States.
3. State the trade names of the three outboard motor lines manufactured by Outboard Marine Corporation.
4. State the trade names of the two outboard motor lines offered by Mercury Marine.
5. List the names of three major Japanese manufacturers of outboard motors.
6. Recognize and name each of the following outboard motor major components:
    - Stern bracket
    - Swivel bracket
    - Gearcase/Foot
    - Skeg
    - Antiventilation plate
    - Steering torque tab
    - Midsection/exhaust tower
    - Engine pan
    - Motor cover/hood
    - Power head
    - Tiller arm
    - Steering arm and link arm
7. Identify In-Line cylinder blocks and their cylinder numbering scheme.
8. Identify V cylinder blocks, their port and starboard cylinder banks, and their cylinder numbering scheme.

LEARNING ACTIVITIES:
1. Participate in class lectures and discussions. (Objectives 1 - 8)
2. View manufacturer's product-line videotapes.
3. Go into the shop and practice you ability to recognize the major components on the outboard motors that you find there. Note the manufacturers' names and the specific product names. If you do not recognize some part of a motor try to locate the service manual and determine its name and function.

EVALUATION/CHECK-OUT:

MODULE 05.02

The instructor will evaluate your ability to recognize outboard motor manufacturers and outboard motor major components by quizzing you verbally. Your performance will be recorded on the performance checklist.

RESOURCES:

LEARNING MATERIALS:

1. Reference
   Manufacturer's service manuals

EQUIPMENT:

1. Examples of outboard engines.

AUDIO VISUAL MATERIALS:

1. Manufacturer's product-line videotapes.
   These are the tapes produced by manufacturers to display and announce their engine product-lines.

NAME________________________ **STUDENT NO.**________________________

05.02 **PERFORMANCE CHECKLIST**

MODULE : IDENTIFYING MARINE PROPULSION SYSTEMS

COMPETENCY: Recognize and name various types of marine propulsion systems

1. ☐ Recognized and named inboard drives
2. ☐ Recognized and named inboard V-drives
3. ☐ Recognized and named I/O drives
4. ☐ Named outboard motor manufacturers and product lines
5. ☐ Recognized and named outboard engine major components
6. ☐ Distinguished in-line and V block powerheads
7. ☐ Identified in-line block cylinder numbers
8. ☐ Identified V block cylinder numbers
9. ☐
10. ☐
11. ☐
12. ☐
13. ☐
14. ☐
15. ☐

COMPETENCY ACHIEVED? ☐ **YES** ☐ **NO**

EXPLANATION:

MODULE 05.03

BOAT TOWING AND HANDLING **INSTRUCTOR GUIDE**

COMPETENCY:

1. Tow boats to and from test lake.
2. Launch and haul out boats at test lake.
3. Operate boats at test lake.

INSTRUCTIONAL OBJECTIVES:

The Student will be able to:

1. Locate and list the State regulations governing the use of boat trailers on roads and highways.
2. State the rule-of-thumb trailer tongue weight.
3. Connect a boat trailer to a towing vehicle.
4. Demonstrate trailer towing, turning, and backing skills.
5. State the purpose of a boat launch checklist.
6. Look up boating safety equipment requirements.
7. Tow a boat to the test lake, launch it, and haul it out.
8. Demonstrate the procedure for fastening a line to a cleat.
9. Demonstrate boat docking procedures.
10. Follow "Rules of the Road" when operating boats in the test lake.
11. Follow safe fueling procedures for boats with portable and built-in fuel tanks.

LEARNING ACTIVITIES:

1. In the State Driver's Handbook locate and read the rules and regulations governing the towing of boats.
   (Objectives 1, 4)
2. Read Chapters 2 - 5, and 10 in the United States Coast Guard's "Boating Skills and Seamanship" book.
   (Objectives 3 - 11)
3. View videotape "Power Boating Volume II. Single Screw Boat Handling, Trailerable".
   (Objectives 1 - 11)
4. View the videotape "The New Boater's Video".
   (Objective's 1 -11)
5. Practice your boat towing skills by hooking a boat and trailer rig to a towing vehicle and driving the rig. Practice turning and backing.
   (Objective 4)
6. Practice launching and hauling out a boat at the test lake.
   (Objectives 4, 7)
7. Practice operating a boat at the test lake. Practice docking and tying up procedures.
   (Objectives 8 - 11)

EVALUATION/CHECK-OUT:

MODULE 05.03

The instructor will observe your boat towing and handling skills as you take boats to the lake for testing. Your ability to do the following will be evaluated:

- Connect boat/trailer rig to towing vehicle
- Tow the rig to the test lake
- Follow State and local towing regulations
- Launch and haul out a boat
- Operate a boat
- Dock and tie up a boat

Your performance will be recorded on the Performance Checklist.

RESOURCES:

LEARNING MATERIALS:

1. Reference
   "Boating Skills and Seamanship",Tenth Edition, First Printing, 1988
   United states Coast Guard Auxiliary National Board, Inc.
   Washington, DC 20593

2. Reference
   State Driver's Handbook

EQUIPMENT:

1. A boat on a trailer and a towing vehicle each properly outfitted with safety gear.

AUDIO VISUAL MATERIALS:

1. Videotape
   "Power Boating Volume II. Single Screw Boat Handling, Trailerable".
   Neptune Productions
   9770 San Fernando Road
   Sun Valley, CA 91352

2. Videotape
   "The New Boater's Video".
   AM Tech Video, Inc.
   6601 Smith Rd.
   Cleveland, OH 44130
   (216) 676-0441

NAME____________________________ **STUDENT NO.**____________________________

05.03 **PERFORMANCE CHECKLIST** 1 of 3

MODULE : BOAT TOWING AND HANDLING

COMPETENCY: Tow boats to and from test lake

1. ☐ Conducted boat/trailer pre-tow safety inspection
2. ☐ Hooked boat/trailer rig to towing vehicle
3. ☐ Executed left and right hand turns
4. ☐ Executed backing maneuvers
5. ☐ Observed state and local towing regulations
6. ☐ Checked boat for presence of required safety equipment
7. ☐ Started boat before towing it to lake
8. ☐
9. ☐
10. ☐
11. ☐
12. ☐
13. ☐
14. ☐
15. ☐

COMPETENCY ACHIEVED? ☐ **YES** ☐ **NO**

EXPLANATION:

NAME________________________ **STUDENT NO.**________________________

05.03 **PERFORMANCE CHECKLIST** 2 of 3

MODULE : BOAT TOWING AND HANDLING

COMPETENCY: Launch and haul out boats

1. ☐ Conducted pre-launch safety inspection
2. ☐ Installed drain plugs
3. ☐ Removed tie downs
4. ☐ Attached bow line
5. ☐ Backed trailer down ramp to water
6. ☐ Released winch cable
7. ☐ Backed boat and trailer into water
8. ☐ Backed boat off trailer
9. ☐ Positioned trailer in water for haul out
10. ☐ Drove boat onto trailer
11. ☐ Tilted engine
12. ☐ Attached winch cable
13. ☐ Hauled boat out
14. ☐ Installed tie downs
15. ☐ Removed drain plugs

COMPETENCY ACHIEVED? ☐ **YES** ☐ **NO**

EXPLANATION:

NAME______________________________ **STUDENT NO.**______________________________

05.03 **PERFORMANCE CHECKLIST** 3 of 3

MODULE : BOAT TOWING AND HANDLING

COMPETENCY: Operate boat

1. ☐ Executed safe turns to port and starboard
2. ☐ Set trim angle for optimum operation
3. ☐ Followed "Rules of Road" when encountering boat traffic
4. ☐ Docked and tied boat up
5. ☐
6. ☐
7. ☐
8. ☐
9. ☐
10. ☐
11. ☐
12. ☐
13. ☐
14. ☐
15. ☐

COMPETENCY ACHIEVED? ☐ **YES** ☐ **NO**

EXPLANATION:

UNIT 6 - GASOLINE ENGINES

MODULE 06.01

FUELS and FUEL ADDITIVES — INSTRUCTOR GUIDE

COMPETENCY:

Select outboard motor fuel and additives.

INSTRUCTIONAL OBJECTIVES:

The Student will be able to:

1) State the meaning of gasoline octane rating.
2) State the names of the three methods for rating gasoline octane equivalency.
3) State the types of energy involved in converting gasoline into motion.
4) Define terms related to the gasoline combustion process.
5) Explain the effects of temperature and humidity on stored gasoline.
6) State the types of gasoline additives which are allowed to be put into outboard motor fuel and explain their effects.
7) Select outboard engine fuel at the filling station.

LEARNING ACTIVITIES:

1) Participate in class lectures and discussions. (Objectives 1 - 7)
2) Read the following information sheets:
   - Article : "Living With Unleaded" by Marlan Davis
   - Article: "Booster Shot" by Marlan Davis
   - Pamphlet: "Know what you're putting in your tank, Facts on alcohol blend fuels"
   - Article: "Alcohol: The final word (hopefully) on the no-lead, alcohol-additive fuel controversy and what it means to trailerboaters"

   (Objectives 1 - 7)
3) Go to the filling station an select outboard motor fuel. (Objective 7)
4) Look up manufacturer's recommendations for outboard motor fuel and additives in service manuals and service bulletins. Record the information you find on the Fuels and Additives Worksheet. (Objectives 6, 7)

EVALUATION/CHECK OUT

1) Turn in your Fuels and Additives Worksheet.
2) Turn in your Terms Worksheet.
3) Take Gasoline multiple choice test and score 70% or better.

RESOURCES:

LEARNING MATERIALS:

MODULE 06.01

1) Article
"Living With Unleaded" by Marlan Davis
Hot Rod Magazine Engines
Petersen's Yearbook Series
Volume 2, Number 2, 1988
Petersen Publishing Company
8490 SUnset Blvd.
Los Angeles, CA 90069
(213) 854-2222
(master copy included in this guide)

2) Article
"Booster Shot" by Marlan Davis
Hot Rod Magazine Engines
Petersen's Yearbook Series
Volume 2, Number 2, 1988
Petersen Publishing Company
8490 SUnset Blvd.
Los Angeles, CA 90069
(213) 854-2222
(master copy included in this guide)

3) Pamphlet
"Know what you're putting in your tank, Facts on alcohol blend fuels"
United States Coast Guard,
BOAT/U.S. Foundation
880 S. Pickett St.
Alexandria VA 22304
(master copy included in this guide)

4) Article
"Alcohol: The final word (hopefully) on the no-lead, alcohol-additive fuel controversy and what it means to trailerboaters"
Trailer Boats Magazine, Vol 15, No. 1, Jan 1986
16427 South Avalon
P.O. Box 2307
Gardena, CA 90248
(213) 323-9040
(master copy included in this guide)

5) Information Sheet
"Detonation and Preignition Causes"
Taken from Mercury Marine Outboard Service Training Notebook.
(master copy included in this guide)

EQUIPMENT:

(none required)

AUDIO VISUAL MATERIALS:
(none used)

MODULE 06.01

FUELS and FUEL ADDITIVES WORKSHEET

NAME:______________________________ STUDENT NO.____________________

MANUFACTURER 1

FUEL RECOMMENDATION -

SERVICE MANUAL WHERE FOUND - PAGE -

LIST OF RELATED SERVICE BULLETINS
(include number and date)

MANUFACTURER 2

FUEL RECOMMENDATION -

SERVICE MANUAL WHERE FOUND - PAGE -

LIST OF RELATED SERVICE BULLETINS
(include number and date)

MODULE 06.01

FUELS and FUEL ADDITIVES TERMS WORKSHEET

NAME:______________________________ **STUDENT NO.**____________________

1. Octane -

2. Knock/Ping -

3. $\frac{R + M}{2}$ -

4. Flame Front -

5. Detonation -

6. Chemical Energy -

7. Heat Energy -

8. Boyle's Law

9. Mechanical Energy -

10. Phase Separation -

MODULE 06.01

FUELS and FUEL ADDITIVES Multiple Choice Test

NAME:______________________________ STUDENT NO.____________________

1. Alcohol attracts

   a. winos.
   b. water.
   c. hydrocarbons.
   d. tetraethyl lead.

2. Marine fuel conditioners contain

   a. isopropyl alcohol.
   b. tetraethyl lead.
   c. toluene
   d. anti knock compounds.

3. Octane is a measure of

   a. gasoline power.
   b. alcohol content.
   c. knock resistance.
   d. burn speed.

4. Engine knock occurs when

   a. the spark plugs foul out.
   b. the carbs get wet.
   c. the engine develops rod endplay.
   d. the fuel/air mixture in the cylinder explodes at the wrong time.

5. The engine damage that occurs because of knock/ping is caused by

   a. the severe shock resulting from the sudden explosion of fuel.
   b. backfires through the carbs.
   c. reed valve failure.
   d. failure of engine seals.

6. Fuel phase separation is

   a. what happens in the cylinders.
   b. caused in gasoline containing ethanol/methanol when

it absorbs too much water.
c. part of the production process.
d. not found in marine fuel tanks.

7. Usually the best fuel to use in outboard motors made before unleaded gas is

a. any gas as long as it has some lead.
b. gasoline with as much alcohol as possible.
c. the highest octane gasoline available at the pump.
d. none of the above.

8. The pressure that pushes a piston down in a cylinder comes from

a. the higher outside pressure.
b. the production of the exhaust gasses.
c. the explosion of the fuel/air mixture.
d. the expansion of air caused by the heat of burning fuel.

9. Preigntion is generally caused by

a. a hot spot in the cylinder.
b. faulty ignition parts.
c. bad piston rings.
d. defective spark plugs.

10. The best way to keep water from condensing in a fuel tank is to

a. use non-metallic tanks.
b. keep the tank full to the top.
c. keep the tank completely empty.
d. move to Arizona.

MODULE 06.01

FUELS and FUEL ADDITIVES Multiple Choice Test

ANSWER KEY

1. B
2. A
3. C
4. D
5. A
6. B
7. C
8. D
9. A
10. B

NAME____________________________ **STUDENT NO.**____________________________

06.01 **PERFORMANCE CHECKLIST**

MODULE : Fuels and Fuel Additives

COMPETENCY: Select outboard motor fuel and additives.

1. ☐ Look up fuel specifications for outboard motors.
2. ☐ Select outboard fuel at the fuel pump.
3. ☐ Select fuel additives.
4. ☐ Take test.
5. ☐ Score
6. ☐
7. ☐
8. ☐
9. ☐
10. ☐
11. ☐
12. ☐
13. ☐
14. ☐
15. ☐

COMPETENCY ACHIEVED? ☐ **YES** ☐ **NO**

EXPLANATION:

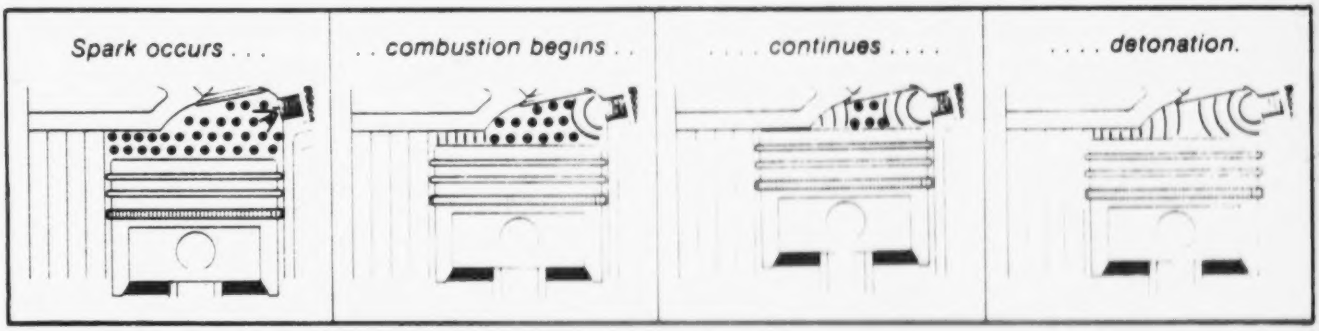
Detonation Causes

Preignition Causes

Sometimes you'll get a complaint of "knock" or "ping". This condition is one of the most common type of abnormal combustion and it works this way:

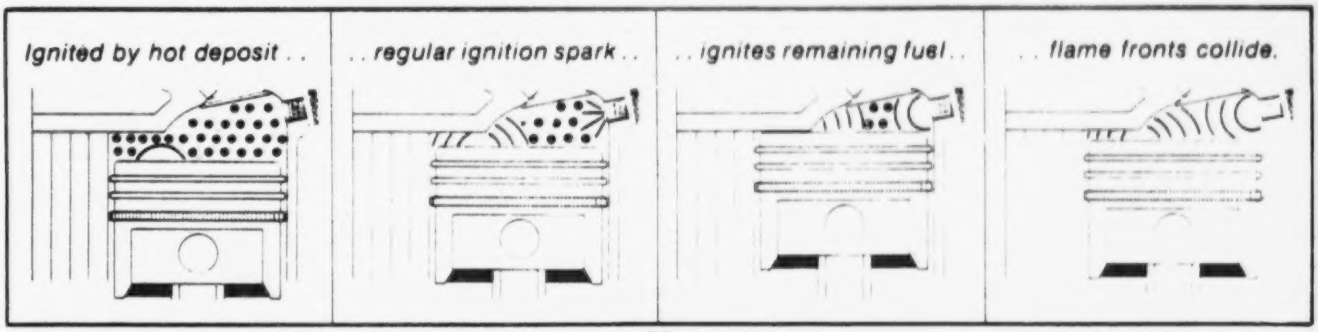
The spark plug fires and the fuel charge begins to burn in a normal manner. But as heat and pressure build up, a portion of the yet *unburned* charge may actually explode, causing high frequency vibrations, which your customer's ear picks up as knock or ping.

Besides the annoying severe cases the engine may even be damaged. Engine knock can be encouraged by wrong ignition timing and/or using fuel with insufficient octane rating. If knock occurs only at high speed, it may go undetected (inaudible detonation) because of the high wind noise. (This is a perfect set-up for engine damage with no apparent reason.)


Spark occurs . . .
. . combustion begins . .
. . . . continues . . . .
. . . . detonation.

Preignition means that the fuel charge is ignited *before* the timed spark occurs and is caused by hot spots in the combustion chamber. Glowing deposits in the combustion chamber, overheated spark plugs or inadequate cooling all can cause preignition.

The result of preignition may range from loss of power to extensive (and expensive) engine damage! Overadvanced ignition timing, low octane fuel and sustained knock will also encourage preignition.


Ignited by hot deposit . .
. . regular ignition spark . .
. . ignites remaining fuel . .
. . flame fronts collide.

FUEL SYSTEM INSPECTION CHECKLIST

These four potential hazard spots should be checked carefully before each outing to prevent a possible fire or explosion on your boat.

✓ **Inspect all fuel hoses,** especially the fuel feed line, for signs of deterioration. Squeeze the hose. Check carefully around the clamped ends. If the hose feels swollen, spongy or mushy, or appears elongated, it is alcohol-permeated. Replace it immediately with SAE J1527 hose. If you detect moisture or dampness on the exterior of the hose, or it smells of gas vapor, the hose is permeated. Replace it.

✓ **Cracked, brittle hose** This is more prevalent in fuel lines that drain back into the gas tank when idle, and in fuel fill and vent lines. Cracked, brittle hose will leak fuel, and should be replaced immediately.

✓ **Bilges** Use your best fume detector — your nose — to sniff for gasoline residue in the bilge. Ventilate your boat well at least five minutes before starting the engine every time. If you still smell gasoline, find the source and make all necessary repairs before you start the engine.

✓ **Fuel tank corrosion** Carefully inspect your fuel tank for signs of wetness, flaking, rust spots or other corrosion. The part of the tank most likely to corrode is the lowest corner or seam. If you see any signs of corrosion or weak metal, replace the fuel tank **before** it starts to leak. An ounce of prevention here could save your life.

DETECTING ALCOHOL IN YOUR FUEL

Check fuel pump labels if your state requires them. Compare with your manufacturer's recommendations.

Inexpensive commercial detection kits to test fuel for the presence and type of alcohol are available. Or, you can test for alcohol yourself. . . .

EASY HOME TEST FOR ALCOHOL

- Place equal amounts of water and gasoline in a glass container with a lid.
- Mark a line exactly where the two liquids separate.
- Shake the container for about one minute, then let it stand for several minutes.
- If there is alcohol present, it will combine with the water and increase the volume in the bottom half of the container; the separation point of the liquids will now be above the line you marked.
- If there is no alcohol, the original 50/50 gasoline-to-water ratio will still be visible right at the place you marked.

United States Coast Guard

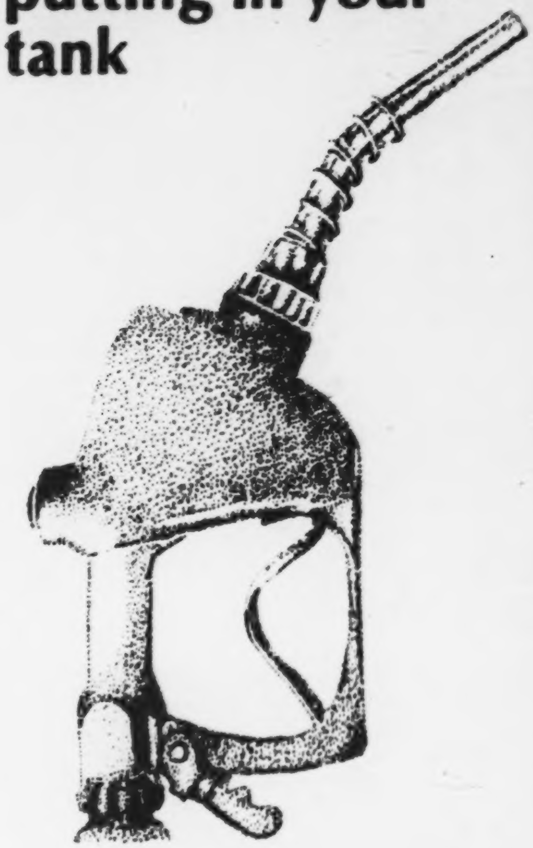
BOAT/U.S. Foundation

For the Boat Handling Course nearest you

Call Toll-Free 800-336-BOAT

BOAT/U.S. Foundation
880 S. Pickett St., Alexandria VA 22304

Know what you're putting in your tank



FACTS ON ALCOHOL BLEND FUELS

BOATER'S 6 PACK

LEAD IS OUT . . . ALCOHOL IS IN!

Since the Environmental Protection Agency ordered lead phased out of gasoline, some oil refiners and distributors have been adding alcohol to gasoline to maintain high octane ratings in the absence of lead.

Unleaded, "super unleaded", and high octane premium gasolines may be blended with ethanol (grain alcohol), or methanol (wood alcohol). The EPA limits ethanol content in unleaded fuel to 10%; methanol is limited to 5% with cosolvents. There are no limits on the amount of alcohol **leaded** fuel may contain.

When oil prices are high, oil refiners and distributors find it cost effective to add cheaper methanol to fuel as a low-cost extender, thereby boosting profits. Ethanol-blend fuels are widespread in farm states and in the Midwest, where tax incentives and government subsidies make ethanol (made from corn and grain) economically attractive for use in motor fuels.

Alcohol-blend fuels pose two problems for boaters. First, alcohol damages rubber fuel hoses, leading to fuel leaks. Second, alcohol corrodes metal, including fuel tanks. Fuel and gas vapors leaking from hoses and tanks will collect in the bilge, creating a serious hazard of fire or explosion on your boat.

CONTAINS ALCOHOL

ETHANOL 10 %

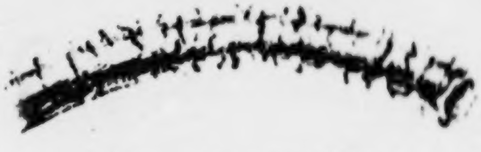
Meets Applicable ASTM Federal & State Regulations

CONTAINS ALCOHOL

METHANOL 5 %
COSOLVENT 2.5 %

Meets Applicable ASTM Federal & State Regulations

Recommended dispensing pump label format.



Fuel Hose: Victim of Alcohol

ALCOHOL MAY DESTROY FUEL HOSES

Alcohol in motor fuels attacks and destroys the plastic elements in rubber hose. This reduces hose flexibility, leading to hard, brittle hose that can crack and leak fuel.

Alcohol can also damage hoses by permeation, or seepage. Pure gasoline will permeate a fuel hose; alcohol permeation accelerates the natural aging process of the hose. This often occurs in fuel feed lines, which are constantly filled with gasoline. A 10-foot section of permeated hose can leak up to one cup of fuel per day. The hose will become swollen, mushy and "weepy", allowing dangerous gasoline vapors to seep through the rubber.

REPLACEMENT: NEW ALCOHOL-RESISTANT J1527 HOSE

The Coast Guard has adopted new safety standards for fuel hoses. When the new hose regulation takes effect in late 1987, all newly-manufactured boats must be equipped with SAE J1527 hose, which is six times more alcohol-resistant than the old standard SAE J30. All fuel hoses on your boat should be checked carefully before each outing. Any hose showing signs of wear or deterioration — cracks, or swollen and "mushy" — should be replaced immediately with J1527 hose. J1527 hose is already widely available for owners who wish to retrofit their boats as a fuel system safety precaution.

ALCOHOL MAY CORRODE METAL FUEL TANKS

Metal fuel tank corrosion occurs through a process called "phase separation." When a tank of fuel sits idle for several weeks or months, water condenses and collects in the tank. Alcohol in the fuel will absorb the collected water. If enough water is absorbed, the mixture separates into two layers: a gasoline-rich layer on top, and an alcohol-water layer that settles to the bottom of the tank.

The alcohol-water "phase" formed by this separation is highly corrosive, and may corrode completely through a metal fuel tank, or cause rust to flake off and clog fuel filters. All metal gas tanks can be corroded by alcohol-laced fuel — whether made of galvanized steel, aluminized steel, aluminum plate or "terneplate" (outlawed for use in boats manufactured after the 1978 model year). To prevent water from collecting in your fuel tank when your boat sits idle for more than a few weeks, either fill the tank full or drain it dry.

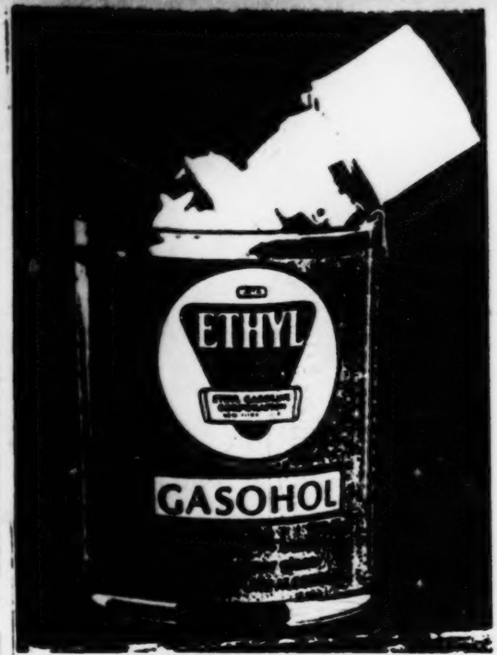
Gasoline additives that absorb water are available. Many contain ethanol or methanol. Do not purchase any fuel additives unless the label clearly states the product contains no alcohol — you don't want to add **more alcohol** to your gas tank.

WHAT KIND OF FUEL SHOULD I USE?

Be aware that some manufacturers will void your engine warranty if you use alcohol-blend fuels, or if the percent of alcohol in your fuel exceeds a certain limit (usually 10% ethanol or 5% methanol with cosolvents).

There are currently no federal alcohol labeling requirements for fuel pumps, although most states require labels stating the fuel contains alcohol and what type. If your state has no pump labeling laws, the only way to determine the alcohol content of the fuel you are using is to test it yourself. (See back panel.)

To find out what type of fuel you should use and what, if any restrictions on alcohol content apply to your engine, check your marine engine manual, your dealer, or contact the manufacturer directly.



ALCOHOL

The final word (hopefully) on the no-lead, low-lead, alcohol-additive fuel controversy and what it means to trailerboaters

BY DON SHARP

Last March (1985), the Environmental Protection Agency (EPA) finally dropped the other shoe. The lead content of leaded gasoline was to have been dropped to 0.5 gram per gallon by July (1985), thence to 0.1 gram per gallon by January (1986) and would disappear completely by 1988.

The announcement raised two questions: First, what would reduced lead content do to engines, particularly older engines? Second, what would substitutes for lead do to engines and fuel systems?

To give some qualified good news first. Leaded gasoline will, in fact, have more like 0.3 gram lead per gallon through 1986, instead of the 0.1 gram required by the EPA. Upon getting the 0.5-gram-per-gallon word in early 1985, major refiners promptly reduced lead content to 0.3 gram. The EPA allows refiners to have an "account" in which they can "save" lead content. By reducing lead content early, the refiners earned a "credit." This allows refiners to exceed lead-content minimums as long as they can "draw" on their credits. Therefore, they earned credit to the extent of 0.2 gram per gallon, which they will apply to the 1986 lead account and thus keep lead content at 0.3 gram during 1986.

Refiners arrived at 0.3 gram as the minimum lead content that would achieve the purpose for using lead in the first place; namely, to suppress aberrant combustion events subsumed under the rubric of "gas knock" and, as a fringe benefit, to provide lubrication for the valves in the form of lead constituents. Their experiments showed that 0.3 gram was the minimum that would get the job done. Thus, the EPA 0.1-gram specification is useless. If lead content goes that low, it might as well be omitted entirely. Accordingly, the major refiners lowered lead content to the useful minimum in 1985, banked their credits for 1986 and don't intend to bother with lead in 1987.

However, what the major refiners give up on may become a hustler's opportunity. With an official EPA specification of 0.1 gram, a refiner can add the useless 0.1 gram and sell the product as "leaded" gasoline to unsuspecting consumers who think they're getting the full benefits of leaded fuel. Accordingly, watch for changes in the EPA lead specification in 1986. If no change occurs, assume that gasoline labeled "leaded" in 1987 will have only 0.1 gram and will not, in fact, provide the benefits associated with leaded fuel.

Lead—specifically tetraethyl lead—has been added to gasoline since 1926 to suppress knock. Once in use, lead revealed itself as an effective lubricant for the sealing surfaces of valves and valve seats, particularly those of the exhaust valves. Thus, for roughly the next 50 years, valves in domestic automobile engines seated directly on the parent metal of the block or cylinder head. By contrast, European engines commonly used hardened valve-seat inserts that were pressed into machined recesses in the valve ports, to be too hard to live with.

When the phase-out of leaded fuel began in the early 1970s, domestic engine manufacturers began induction-hardening the surfaces of the valve seats. Induction-hardening is a sort of middle-ground between no hardening and a separate, hardened valve-seat insert. Induction-hardening works well enough in automotive applications, given that the average 200-hp automotive engine develops only 50 hp or less when moving a car on the level at 60 mph or so. However, it is less satisfactory for marine service where the same engine operates at nearer the 150-plus-hp level. In marine service with unleaded fuel, induction-hardened seats are expected to last only about half as long as they would with 0.3-gram-per-gallon leaded fuel.

However, the piston rings of marine engines typically wear out long before the valves, so reduced valve life may simply mean that rings and valves will wear out at the same time, and the net consequence to the boat owner—i.e., the need to overhaul or re-power—will be unchanged.

The loss of leaded fuel is more consequential to older engines that do not have induction-hardened valve seats. Such engines will burn their valves promptly and can be salvaged only by the installation of valve-seat inserts or by swapping the cylinder heads for newer ones with induction-hardened seats. Depending on local circumstances, the cost to swap heads or to get valve seats into the heads will cost around $400 for parts, machine-shop work and gaskets, with basic labor adding another $200. (Options and costs of introducing hardened valve seats into the engine were more fully discussed in *Trailer Boats Magazine*, September 1985.)

This distressing prognosis applies to all boat engines manufactured by the Big Three automobile companies prior to the 1973 model year and, in some cases, p to 1975 (check with a dealer). The old Palmer V-8s and sixes, which came from International Harvester, have hardened inserts and sodium-cooled valves and will tolerate unleaded fuel.

To resolve the question of valve life, even in an unhappy way, still leaves the question of knock. Generally, automotive-based marine engines will run satisfactorily on 86-octane gasoline, an octane level low enough to include virtually all gasoline sold. However, if all Ford and Chevrolet V-8s are equal to their congeners when they leave Detroit, the several marinizers do not let them remain so: different carburetors and ignition systems may mean that some engines require higher octane fuel. To use lower octane fuel will require resetting the ignition timing, usually by retarding it a few degrees, i.e., making the spark occur later relative to piston travel.

Despite Detroit's use of induction-hardened valves, and despite the fact that unleaded fuels are available in up to a 93-octane rating, some marinizers still specify "leaded" fuel. Although th marinizers do not explain why the specify, their reluctance actually arises from the hazards of consumer protection law. However, their recommendations become a nullity and will have to be ignored after January 1, 1987, since leaded gasoline won't exist (unless the EPA [illegible]nges its mind). If the marinizer speci[illegible]s leaded fuel, the boat owner should ask about the ignition timing adjustments that will make the engine compatible with unleaded fuel.

Outboards present no differences of kind or degree. Some outboards from about 15 years ago require leaded fuel to provide piston ring lubrication. The advent of unleaded fuel will make scrap metal of these; check with a dealer about specific models that will be affected. Otherwise, modern outboards, meaning those built in the last 10 years, don't need leaded fuel and can proceed confidently into the unleaded era, although manufacturers may specify leaded fuel for some of the big, hairy vee-types. However, the specification involves knock rather than wear, so ignition timing adjustments will allow these units to run on unleaded fuel also.

The foregoing fairly well covers the consequences of removing lead. The next issue is that of substitutes for lead. For the past 10 years, such hydrocarbons as toluene and benzol have been added to gasoline to suppress knock. Though cost[illegible] such hydrocarbons work well and [illegible]parently cause no damage to engines or fuel systems. Alcohol in about a 10-percent concentration also suppresses knock and is considerably cheaper than toluene, benzol, etc. However, alcohol is both corrosive and destructive; the cheaper form, methanol, is the most destructive of all. Since many refiners can be expected to resort to methanol as a cheap knock-suppressant (i.e., octane "booster"), the questions becomes: What will methanol do to engines and fuel systems?

The answer is: Nobody really knows, but those who have been looking into the matter don't like the idea of alcohol, particularly methanol, in engines, especially marine engines.

At this point, the discussion must digress from the path of sweet reason and dispatch some popular mythology surrounding alcohol-based fuels.

1) First, methanol has only about half the energy value of gasoline. If all other factors are equal, and if one engine runs on pure methanol and another on gasoline, the methanol-fueled engine will [illegible]velop only half as much horsepower. [illegible] the country were to convert totally to methanol fuel, all engines would have to be twice as big and would burn twice as much methanol (compared to gasoline). Or, all engine-powered devices would do only half as much work.

2) Methanol does burn at a slower rate and it burns even slower if mixed with nitrogen. Thus, the nitro-methane injected into racing engines is not some hyper-powerful fuel. Rather, it is a notably effective knock suppressant and is used in racing engines so that compression ratios can be raised to extreme limits. A high-compression ratio gets more heat energy out of a unit of fuel, but it also brings on knock. Nitro-methane compounds suppress knock, but they do not contribute to the power the engine develops. Competition engines that run on pure methanol usually have extremely high compression ratios and are either supercharged or turbocharged up to 30 pounds of boost or more, and so require the knock resistance of methanol.

3) Yes, during World War II and after, various multi-fuel military trucks did run on 35 percent alcohol, which proves alcohol will work (if anyone doubts the fact; in fact, an engine will run on sawdust or cornstarch, if *tours de force* be the goal). However, these trucks did not perform as well as their gasoline brethren and, given that alcohol evaporates more readily than gasoline, were hampered by vapor lock in hot weather and carburetor icing in cold climates. To have vehicles stalled for either reason hardly seems like progress.

4) And, yes, Brazil has reportedly run its vehicles on alcohol blends for 50 years. The practice arises from the faulty economics of excluding imported oil while trying to exploit more-expensive, home-grown biomass, specifically sugar cane, as an alternative. Brazil is not a country noted for the economic sagacity of its political dispensation (or much else except the fanaticism of its soccer fans). →

About Dehydrators

Everybody understands that fuel burns in an engine, i.e., combines with oxygen from the air to release heat. However, not everyone realizes that fuel burns as it sits in the tank, too.

The burning that occurs in the tank proceeds much more slowly and is not so thorough as the burning that takes place in the engine. Hence, its combustion by-products are different. Generally, in both gasoline and diesel fuel, oxidation residues are manifest as a reddish material known as varnish.

In the early stages, varnish is a gummy substance that is soluble in the fuel in which it forms. In the later stages, it hardens into an insoluble form. In either form, it can clog fuel filters, fuel pumps and carburetors of gasoline engines. In diesel engines, it accumulates on the inside walls of high-pressure, fuel-injection lines and injectors, compromising fuel flow.

Varnish aside, fuel that is already partly burned does not burn well once it gets into the combustion chamber. It makes an engine hard to start and causes it to run erratically once it does start.

Water in fuel does not contribute to the slow oxidation so much as complicate the chemical reactions involved, either to accelerate them, to create more complex by-products or both. In addition, water will clog a paper-element fuel filter in a gasoline system and will displace the fuel that lubricates the injection pump and injectors in a diesel system, thus leading to damage to these exquisitely precise mechanisms.

Preventing fuel from degrading while in storage becomes a matter of inhibiting the chemical reactions of slow combustion, a task readily and successfully accomplished by fuel additives classified as stabilizers. However, to inhibit oxidation is not enough: something must be done about the water that invariably gets into a tank. Thus, fuel-tank additives should include a *dehydrator*.

The most common fuel dehydrators, such as those used in automobiles in cold climates to keep ice from forming in fuel lines, primarily consist of alcohol. The alcohol absorbs the water, after which the alcohol-water mix passes through the fuel system.

The advent of alcohol-blend fuels, though, makes alcohol-based dehydrators undesirable for marine service. Alcohol in the dehydrator may be enough to provoke phase separation.

Accordingly, while stabilizers and dehydrators are advisable all the time and are virtually necessary when a boat is laid up, alcohol-based dehydrators should not be added to alcohol-blend fuels. Read labels carefully and eschew those containing alcohol. To do so reduces the choices among dehydrators, but better a narrow choice than a problem in the fuel tank.

Furthermore, the details of the Brazilian experience remain sketchy. A scientist writing a technical paper will observe that "Brazil has long used alcohol-blend fuels," and stop. Something about the experience seems to discourage technical writers from pursuing details. Whatever is going on down there, it hardly provides a model for the United States (except for the bathing suits in Rio).

To return to the subject of methanol in engines—leaving aside the matter of valves—methanol apparently dilutes the oil film that adheres to the upper part of the cylinder. Test vehicles run on 95-percent methanol have suffered premature upper-cylinder and piston-ring wear. However, the use of more expensive, technically superior chrome-plated piston rings seems to resolve the problem. On the other hand, if the methanol concentration does not exceed 10 percent, the problem hardly arises at all.

Methanol has been used experimentally in diesel engines as a way to augment the fuel. If injected into the air supply by an atomizer *after* the engine has been started and warmed up, methanol apparently causes no damage to diesels.

Methanol, then, has no deleterious effects on the engine itself if it constitutes as little as 10 percent of the fuel blend. That matter resolved, the next question is that of damage to fuel-system components, along with the related question of methanol in use.

In general, methanol has been found to damage some fuel-system components, particularly those from the class of synthetics known as elastomers, i.e., elastic polymers. Elastomers are used in gaskets, accelerator pumps, fuel pumps, needle valves and fuel lines. Methanol may cause them to swell, or may dissolve them completely. The prospects include a severely flooded engine, leading to an incendiary backfire that sprays burning fuel out through carburetor gasketry (where the flame arrestor can't intercept it).

Or, if fuel pumps or lines leak, methanol will collect in the bilges and, given its low vapor pressure, will permeate the whole boat with explosive fumes. These fumes ignite more easily than gasoline but do not betray themselves as readily by smell.

In the tank, methanol in a gasoline-methanol blend will absorb moisture from the air. If the proportion of water reaches 0.5 percent of the total liquid (gasoline-plus-methanol) volume, the water and methanol will form a solution of their own, separate from the gasoline and settle to the bottom of the tank in a process known as phase separation. The engine will run haltingly on this mixture, but with accelerated cylinder and piston-ring wear mentioned earlier.

Note the percentages: a boat comes home to dock with six gallons left in the tank, of which 10 percent—a little over a pint—is methanol. As little as one liquid ounce of water—a shot glass full—from condensation or spray leaking through the filler will provoke phase separation. The separation can be prevented by fueling up, thus increasing the total volume so that the water content falls below 0.5 percent. Any such topping up, though, must occur before phase separation begins, since the process won't reverse.

While reposing in the bottom of the tank or proceeding through the fuel lines, the dilute methanol-water solution is highly ionized; that is, it acts like battery acid to provoke galvanic corrosion between dissimilar metals in the fuel system. The net result may be degraded fuel lines, line fittings and carburetor housings.

The potential evils of phase separation were sufficient to cause the National Marine Manufacturers Association (NMMA), the marine industry trade association, to revise the established procedures for lay-up. Hitherto, the NMMA recommended that fuel tanks be topped up for storage, on the argument that full tanks gather less condensed water and contain less explosive vapor than empty ones. The Coast Guard has long agreed with this top-up-at-lay-up procedure.

The corrosive effects of methanol, however, provoked the NMMA to recommend that methanol-bearing fuel be removed from tanks during storage. Unfortunately, and with an embarrassment they acknowledge, the NMMA could not say how to empty a tank. Draining the fuel line leaves an inch or so of fuel below the pickup, the filler pipe is usually too convolute for a siphon hose and tanks no longer have inspection ports. The NMMA recommendation had the virtue of warning of a danger, but it did not resolve all problems.

The foregoing are the bad news possibilities. Now, what is the evidence from the real world to date?

In a word, inadequate. Good evidence will not begin to accumulate until 1987, when more methanol-blend fuel will be used. Until then, the NMMA, the engine marinizers and boat owners can only wonder what the future will bring.

At the risk of being optimistic too soon, the indications are that methanol-blend fuels will cause little trouble to the fuel systems of newer boats. Carl Spiegel of Marine Development and Research, a fuel-system-additive and boat-care-products firm in Freeport, New York "pickled" several sections of fuel-line hose in methanol solutions of various strengths for several months and reported no visible degradation.

In any event, the NMMA and the Coast Guard are working with the Society of Automotive Engineers (SAE) to develop a new performance standard for marine fuel lines. The new standard should be in effect by mid-year (1986), after which the improved hose will go into new boats at the factory. Otherwise, the improved hose will be available from retail outlets for installation in older boats.

Captain Mike Holmes, who examined the alcohol issue in *Trailer Boats Magazine*, April 1985, feels that fouling of paper-element fuel filters may be the most inconvenient consequence of methanol-blend fuel. But Captain Holmes cogently notes that any water trapped in a filter (and clogging it) is most definitely **not** in the fuel tank, and that can be a form of good news in itself.

Elsewhere, researchers for Atlantic Richfield found no damage to fuel-system components in automobiles that ran up to 29 months and 85,100 miles on fue containing 10 percent methanol. Agreed, these results do not transfer directly to marine use. The 21 cars involved were driven every day and refueled regularly; they did not sit at a damp dock for a week or two and suffer phase separation. Nonetheless, 85,100 miles over 29 months represents a lot of exposure to methanol-laden fuel.

This relative good news, however, does not extend to older boats that may have vulnerable fuel-system components. Indeed, manufacturers of carburetors and fuel pumps were not concerned about methanol 10 years ago and may not even know how older components will respond to it.

This "older" business is not well-defined. Basically, it means before the "gasohol" era of 1979. The bottom line is that owners of boats built before 1979 must inspect their fuel systems frequently and carefully. Indeed, given the uncertainties, any owner using methanol-blend fuel must do so. All boat owners must be concerned about phase separation and may need to use a fuel dehydrator that does not—repeat: **does not** contain (more) alcohol. In general, though, the unleaded fuel future does not look too hard to live with.

Continued on page 91

ALCOHOL *Continued from page 38*

To a degree, marine engine manufacturers do not expect, or fear, widespread fuel-system failures. What they do fear are hordes of opportunistic, unprincipled lawyers eager to find a problem, from mere inconvenience to disaster, than can in some remote, tendentious manner be related to a fuel-system failure arising from the use of methanol-blend fuels. Boat owners should keep in mind that the alarm about methanol has been composed under the "cover your assets" (CYA) syndrome and with a wary eye over one shoulder at a rapacious tribe of lawyers. In practice, the results do not promise as much disaster as some public writ would suggest.

Still, anybody who uses methanol-blend fuels, presently or in the future, must keep an eye on the fuel system. As experience accumulates, the problems, or lack of them, will be sufficiently defined and reported in *TBM*. ➤

HIGGINBOTHAM *Continued from 13*

nics for the perpetually hungry mob. And everyone, no matter what their style, was enjoying the time with their boats, family and friends.

It's a long way across this country and back, and sometimes I felt the only thing I'd gained was a new question for Trivial Pursuit. What phrase is used on every McDonald's sign? After counting 143 golden arches I know the answer. Millions and millions sold. But it was fun to board a paddle-wheeler at Vicksburg for our first cruise on the Mississippi. To watch the Greek sponge divers in Tarpon Springs unload their soggy catch. We enjoyed the humor of Hondo, Texas, residents who'd erected a sign saying, "This is God's country. Please don't drive through it like Hell." We stopped by Miss Bessie's restaurant, famous for chicken-fried steak. We gorged ourselves on oysters and shrimp from gulf communities that were hard hit a few days later by hurricanes Danny and Elena. And we marveled, especially on our return, at the big blue skies and wide open spaces surrounding the western lakes.

If you avoid the red ribbons on the maps, and follow the black lines instead to the patches of blue, you can still find the best of America. Where Skipjacks are catching marlin, Sea Rays are shore camping, you can talk oil injection and Duoprops, and find a guy who knows a Prindle is a catamaran, not a potato chip. That's where the fun is.

HOOK UP
MERCRUISER
STERN DRIVE

THE BOOK LOCKER

SERVICE MANUALS

SE10	**OMC STERN DRIVES** covers all models '64-'83. Complete—1100 illustrations 576 pp	$24 95
SE15	**MERCRUISER STERN DRIVES** covers all models '64-'83. Very complete with 1200 illustrations. 528 pages	$24 95
SE25	**MERCURY OUTBOARDS** covers all in-line models '65-'83 Complete with over 1300 illustrations 624 pages	$24 95
SE30	**JOHNSON/EVINRUDE** 1.5-40 hp models '56-'70 Complete with 1200 illustrations & diagrams. 432 pages	$24 95
SE35	**JOHNSON/EVINRUDE** 2.0-60 hp models '71-'81 1500 illustrations & diagrams 608 pp	$24 95
SE40	**JOHNSON/EVINRUDE** 50-125 hp models '58-'72. complete with 1300 illustrations & diagrams. 536 pages	$24 95
SE45	**JOHNSON/EVINRUDE** 65-235 hp models '73-'82. complete with 1200 illustrations & diagrams 384 pages	$24 95
SE50	**VOLVO PENTA STERN DRIVE** covers all models '68-'85. Complete with illustrations & diagrams Over 375 pages.	$24 95
CP12	**MARINER OUTBOARDS** 2-48 hp '76-'84 covers 13 gas and 6 electric models, over 550 illustrations 334 pages	$22 9⁵
CP16	**MARINER OUTBOARDS** 50-200 hp '76-'84 covers all inline & V6 models 344 pp	$22 95
CP70	**CHRYSLER/FORCE** 3.5 to 140 hp outboards 1966-'85. 419 pages	$22.95
CP80	**SUZUKI** 2 to 140 hp outboards 1977-1984 368 pages	$22.95

BUILDING & REPAIR

GL05	**FIBERGLASS BOATBUILDING FOR AMATEURS** a practical "how-to" book written for the amateur. 382 pages	$23.95
GL10	**BOATBUILDING WITH PLYWOOD** takes you from lofting to finish. 288 pages	$16.95
GL15	**INBOARD MOTOR INSTALLATIONS** is "must" reading for anyone installing an engine in a new boat or repowering. 256 pages	$15.95
GL20	**HOW TO FIBERGLASS BOATS** for the beginner with 100 photos & drawings. 120 pages	$9.95
GL25	**HOW TO BUILD BOAT TRAILERS** shows you how at a fraction of factory built trailers cost 92 pages	$7 50
WI01	**CUSTOM BOAT TOP** Construction manual includes diagrams & pictures 32 pp	$6 95

WATERSKIING

PI10	**SKI TIPS** is a complete water skiing instruction book by Tony Krupa. It includes sections on slalom, tricks and jumping 108 pp	$7 95
PI20	**THE COMPLETE INSTRUCTIONAL BOOK OF WATERSKIING** by Joel McClintock outlines how-to from basics to advanced 180 pp	$13 95
PI35	**THE COMPLETE GUIDE TO BAREFOOT WATER SKIING** covers all aspects of barefooting with emphasis on instruction 132 pp	$9 95

GENERAL

WM00	**THE COMPLETE BOOK OF INFLATABLE BOATS** a guide to buying an inflatable. 256 pp	$7 95
WM02	**ROYCE'S SAILING ILLUSTRATED** is a must for every sailor. 26 years in print. 352 pp	$8 95
WM04	**ROYCE'S TRAILERBOATING ILLUSTRATED** for boats to 30' 192 pp	$8.95

TRAVEL

DW10	**LAKE POWELL BOAT & TOUR GUIDE** includes charts & information. 56 pp	$7 95
DW20	**LAKE POWELL & RAINBOW BRIDGE** is a full color pictorial book. 32 pp	$6.95
SJ05	**STAN JONES LAKE POWELL BOATING & EXPLORING MAP** Detailed information	$3 50
BT20	**THE BAJA BOOK II** is one of the most complete books on travel in Baja. 180 pp	$9 95
BT40	**THE BAJA FEELING** is a fast moving narrative of travel and adventure. 336 pp	$7 95
MP01	**BAJA ADVENTURES** by Land Air & Sea is a book that will bring the adventure of Baja right into your living room. 192 pp	$9 95
CG03	**SEA OF CORTEZ GUIDE** by Dix Brow. Covers the entire gulf 272 pp	$19 95
CG10	**RECREATION LAKES OF CALIFORNIA** is a complete guide with detailed maps and information for the entire state 207 pages	$9 95
CG13	**CALIFORNIA COASTAL PASSAGES** gives sailing directions, suggested courses, etc. from San Francisco to Ensenada 160 pp	$16 95
CG15	**CRUISING GUIDE TO THE CHANNEL ISLANDS** has excellent approach photos, anchorage detail and much more 206 pages	$19 95
CG25	**FORAGING ALONG THE CALIF. COAST** by Peter Howorth 192 pp	$5 95
CG40	**CHART GUIDE CATALINA ISLAND** 11th edition by Ed Winlund. All island shoreline and crossing from Mainland plus available services. 16 pp	$7 50
CG45	**CHARTGUIDE SAN CARLOS** by Gerry Cunningham 54 sailing anchorage descriptions all used by author along with 48 photos & 35 charts. 94 pp	$17 95
WM01	**PACIFIC BOATING ALMANAC** So. California, Arizona & Baja. 432 pages	$10.95
WM03	**PACIFIC BOATING ALMANAC** Northern California and Nevada. 432 pages	$10.95
WM05	**PACIFIC BOATING ALMANAC** Oregon, Washington, B.C. & Alaska. 432 pages	$10.95
HS01	**CRUISING & HOUSEBOATING THE DELTA** by well-known Hal Schell. 114 pp	$4.95
HS03	**DAWDLING ON THE DELTA** gives cruising coverage for entire Delta. Hardcover 208 pp	$24.95
HS05	**DELTA MAP** covers entire Delta	$2.95
BW01	**DELTA** The cruising wonderland of California's sloughs and rivers by well-known Bob Walters. Eight years in the making, this book blends timeless factual adventure reading into every cruising corner of the Delta. 270 pp	$19.95

FISHING & DIVING

SJ01	**FISHING LAKE POWELL** by Stan Jones covers techniques for all species. 96 pp	$8.50
CG95	**HOOK UP** includes tackle, gear, bait and techniques for 50 species of fish 133 pp	$8.95
BT10	**ANGLER'S GUIDE TO BAJA CALIFORNIA** Very complete 128 pages	$6.95
CG85	**BAJA CALIFORNIA DIVER'S GUIDE** covers the entire peninsula 220 pages	$12 95
EB02	**THE PERFORMANCE BOAT BIBLE** by well known Earl Bentz is a complete guide to getting the most performance from your boat 220 pp	$12.95

OUTDOOR PRODUCTS, BOX 942, LOS ALAMITOS, CA 90720

Please send me the following books ➤ # ________ $ ________
________ $ ________
________ $ ________
________ $ ________
________ $ ________
Sub Total $ ________
Calif. Residents add 6% sales tax $ ________
Add $1.50 for each book ordered for postage and handling $ ________
TOTAL ENCLOSED $ ________
(U.S. Funds only)

Enclosed is my
☐ Check ☐ Money Order (Sorry, no C.O.D.s)
Please mail to:
NAME ________
ADDRESS ________
CITY ________
STATE ________ ZIP ________

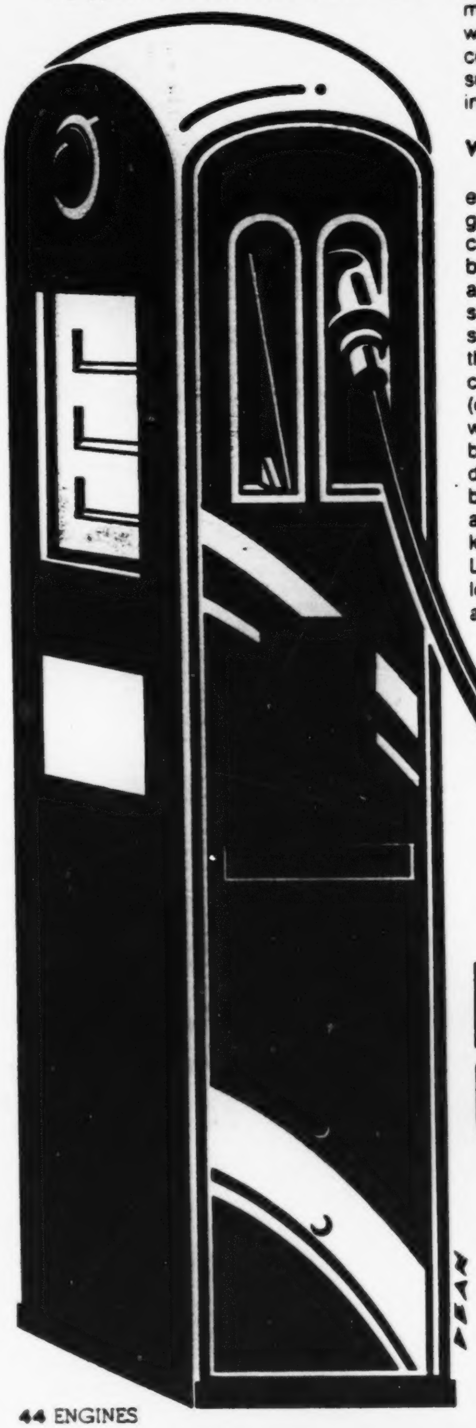
If you are not completely satisfied, you may return your purchase within two weeks for a complete refund. Prices subject to change without notice. Dept. TB

LIVING WITH UNLEADED

UNCLE SAM HAS DECIDED TO "GET THE LEAD OUT" OF GAS—

HERE'S HOW YOUR CLASSIC MUSCLECAR OR HIGH-PERF STREET MACHINE CAN SAFELY KICK THE HABIT

Face it: The lead is coming out. For better or for worse, our EPA who art in Washington has already cut the allowable gasoline lead concentration from 1.1 to 0.1 gram/gallon. They have also proposed to eliminate lead entirely by 1988. Numerous studies have documented lead's harmful environmental and health effects, resulting in the general public's cry to "get the lead out!" Unleaded gasoline is of course mandatory in all catalytic converter-equipped vehicles, because lead "poisons" the catalyst. However, many older engines designed to run on leaded fuels remain in service. Owners of these engines have expressed concern over the possible adverse consequences of using low-lead or unleaded gas in them—concerns aggravated by the sometimes ominous, often contradictory, results of research studies undertaken to determine the possible harmful consequences of unleaded fuel. In an effort to set the record straight, HOT ROD has reviewed the tests and studies, and talked to numerous experts in the field. In this article we'll thoroughly review the unleaded gas controversy, [illegible] well as present some survival techniques for living with the inevitable.



Why Lead?

Tetra-ethyl lead was invented by General Motors engineers in the 1930s. Engineers of the time wanted to increase compression ratios to make more power, but the crude refining technology then available made it difficult to produce gasolines having sufficient anti-knock resistance. The GM engineers discovered that adding tetra-ethyl lead to gas significantly reduced engine knock or "ping" (detonation). An unexpected by-product was increased valve life brought about by lead's lubricating properties. To this day, no other additive compound has been discovered that matches lead's ability to both protect engines from knock and prevent valve seat damage. Lead removal therefore introduces at least a theoretical possibility of additional ping and shortened exhaust valve life in those engines designed to run on leaded fuel.

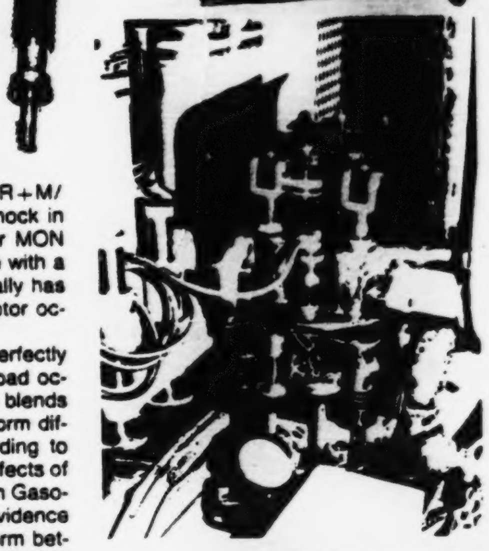
The Octane Game

A fuel's octane number is a rating of its resistance to knock or ping. The higher the number, the more resistant is the fuel to knocking or detonation in a spark-ignition engine. Octane in and of itself is not a measure of power; a given engine in a given state of tune that *isn't* detonating will see no increase in power when run on higher octane gasoline. An engine that *is* knocking on low-grade fuel will achieve a power gain with higher octane gas, because any spark-ignited engine's horsepower curve stops climbing at the point where detonation occurs. Also, a higher-octane fuel will allow an engine to be *tuned* for higher performance: more spark advance, leaner fuel mixture, higher static compression, or more blower boost.

So far, clear enough. Unfortunately, there are several different ways to measure octane. For automobiles, these include the "Research Octane Number (RON)," "Motor Octane Number (MON)," and "R+M/2 Method," the latter being an average of the numbers produced by the first two methods. A special laboratory variable compression ratio engine is used to derive the various octane ratings. RON is measured in the test engine under conditions of constant load, constant rpm, and a cool intake manifold—not at all similar to real-world driving conditions. Yet this is the way gas was rated at the pump back in the '60s; that 105-octane premium was good—but not as good as it sounds.

MON is measured in the test engine under variable load and rpm, and with a hot intake manifold. These conditions more closely approximate real-world driving conditions, but since this test method produces lower octane numbers than the RON method, results were not widely publicized by oil companies. In an effort to end the confusion, the government mandated the average "R+M/2 Method" about a decade ago. But since it's only an average, R+M/2 obscures data useful to the enthusiast in determing how a particular gasoline blend will actually perform in his car. For example, two different gasoline blends may

A special 1-cylinder variable compression ratio engine is used to establish a fuel's octane number. Combustion chamber size is varied by raising or lowering head height by means of a hydraulically actuated worm gear drive.



ELEVATED DISCUSSION

No doubt you've noticed that pump gas sold in high-altitude areas has a lower octane rating. That's because vehicle octane requirements decrease with altitude. Octane requirements are also affected by changes in temperature and humidity. Union Oil Company's Tim Wusz supplied the following rules of thumb:

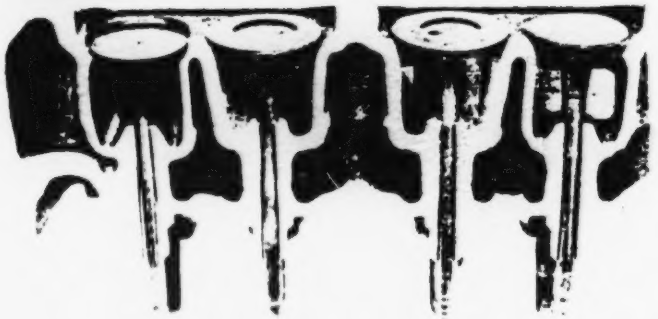
- From 2000 to 5000 feet, vehicle octane requirement is *reduced* by one number per each 1000-foot *increase* in elevation.
- Between 32 to 100 degrees F., vehicle octane requirement is *reduced* by one octane number for each 25-degree F. *decrease* in temperature.
- Vehicle octane requirement is *increased* by one number when the air's moisture content is *reduced* by 33 grains. A "grain" relates to readings taken with wet and dry bulb thermometers and is not a strictly linear relationship, so this one's hard to figure in the "real world."

both be rated at 92 octane by the R+M/2 method, but one blend may knock in your car, because it has a lower MON rating (it makes up the difference with a higher RON). Unleaded gas usually has a higher Research and lower Motor octane rating.

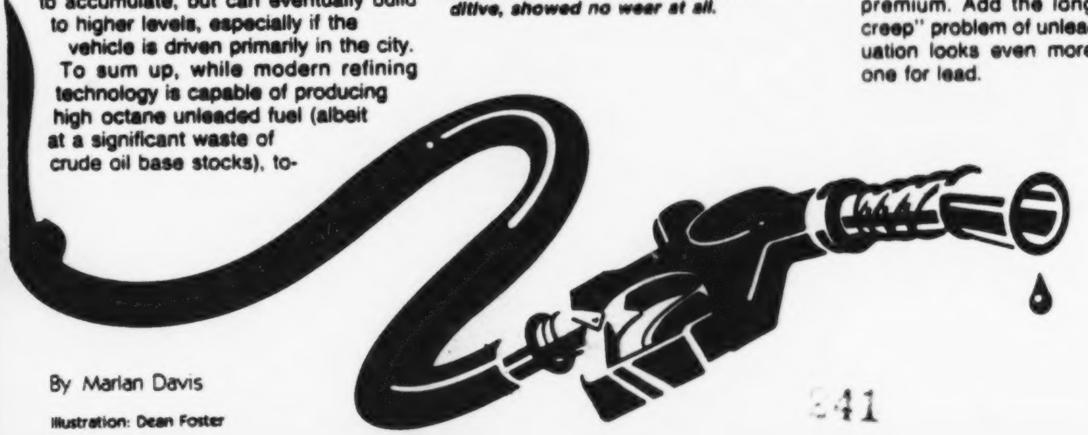
But even the MON test isn't perfectly representative of actual on-the-road octane requirements. Different gas blends with the same MON's often perform differently in the same car. According to the SAE technical paper, "The Effects of Low-Lead and Unleaded Fuels on Gasoline Engines": "There is some evidence that leaded fuels generally perform better in on-road service than do unleaded fuels of equal octane number." The deficiency can be as great as one to two octane numbers for cars originally designed to operate on leaded premium.

Finally, there is "octane requirement creep." As an engine ages, solid deposits accumulate in the combustion chamber. Mechanical compression ratio is thereby increased due to the decreased combustion chamber volume. The deposits also have low heat conduction characteristics, leading to higher chamber temperatures. Add in oil dilution from worn rings and valve guides (which induces detonation), and you end up with a significantly higher octane requirement for a given engine. Leaded fuel deposits build up quickly in the first few thousand miles of operation, then level off. Unleaded deposits take up to 10,000 miles to accumulate, but can eventually build to higher levels, especially if the vehicle is driven primarily in the city.

To sum up, while modern refining technology is capable of producing high octane unleaded fuel (albeit at a significant waste of crude oil base stocks), today's premium octane numbers still don't measure up to those of 15 years ago; 1970-type 100-plus research octane gas would be rated at about 95 to 96 octane by today's R+M/2 method...better than our 92-octane unleaded premium. Add the long-term "octane creep" problem of unleaded, and the situation looks even more dismal. Score one for lead.

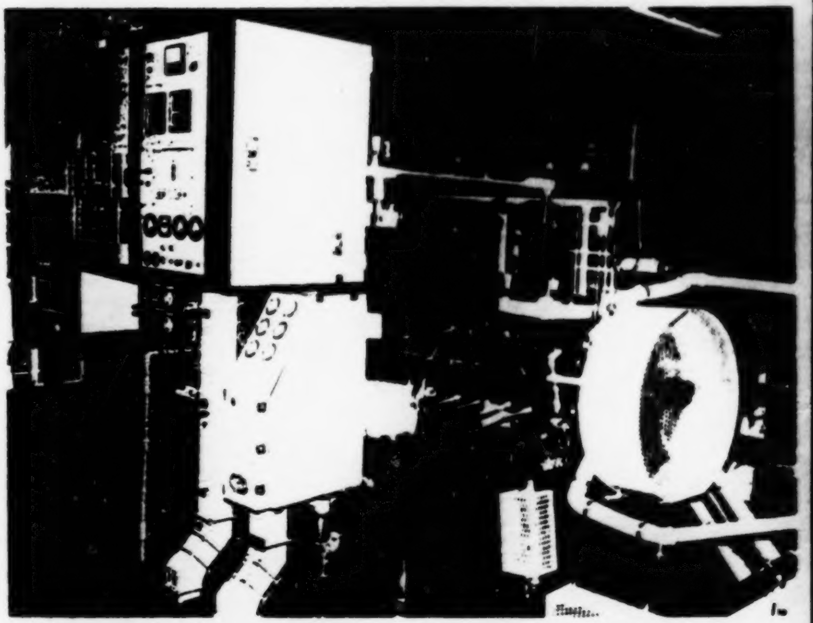


Union Oil tests graphically illustrate the effects of unleaded fuel on exhaust valves when the engine is subjected to constant high load conditions. Left-hand exhaust valve receded over .100-inch, while right-hand valve, protected by Union's new "Unocal 76 Valve Saver" additive, showed no wear at all.



By Marlan Davis

Illustration: Dean Foster



As is typical of most major oil companies, Union Oil of California maintains extensive dyno test and lab facilities to evaluate different fuel and lubricant blends. Some of the "mules" are pretty healthy, like this hopped-up Chevy Mouse motor.

Heading Into Recession?

We mentioned that a happy accidental by-product of lead was its exhaust valve seat lubricating characteristics. Leaded fuel forms lead chlorobromides and other high-temperature solid film lubricants that coat the valve face and seat. The lead "film" prevents cast-iron oxidation and consequent material transfer that ultimately causes a phenomenon known as "valve seat recession." Basically, valve seat recession is initiated by the adhesion of hard, abrasive particles from the exhaust valve seat onto the valve face, followed by seat abrasion due to the scrubbing of the imbedded particles as the valve moves against the seat—kind of like a low-speed metal grinder. In addition to its lubricative properties, lead may also reduce wear by thermally insulating the seat metal from the hot exhaust gases. Most engines can tolerate some degree of valve recession, but if excessive recession does occur, the valve won't seat. Result: cylinder compression leakage, and probably a burnt valve, since 75-percent of exhaust valve cooling is by valve seat conduction of heat into the coolant jacket.

Early laboratory studies seemed to validate high-speed valve seat recession concerns. TRW testers found that upping steady-state engine rpm from 2800 to 4000 rpm under typical road-load power conditions increased recession tenfold, while going to steady-state full throttle at a constant 2600 rpm increased recession by only 50 percent. Other lab tests showed that wear could be reduced two thirds by reducing simulated constant cruising speeds from 70 to 60 mph. However, it turns out that most of the lab studies involved running engines for hundreds of hours at a stretch under constant load and severe operating conditions. In the real world, high speeds and loads occur infrequently, and recession occurs only after all valve seat deposits have been worn away.

The actual daily experiences of private fleet operators, governmental agencies, and (in a series of meticulously documented tests involving thousands of vehicles) the U.S. military—most of which were conducted before the 55-mph speed limit—have clearly demonstrated that unleaded gasoline causes no significant valve or valve seat problems under most conditions. According to the literature, "Continuous high-speed driving represents the most severe operating condition both for valve burning and for valve seat recession."

From this evidence, I'd say not to worry about valve seat recession unless you drive 70 to 80 mph all day. For such driving, various gas additives are available to reduce recession tendencies (more on this next month). Typical SF/CD or SF/CC engine oil containing 1-percent sulfated ash has also been shown to reduce the seat wear rate by ⅓ to ⅔ compared to ashless oils.

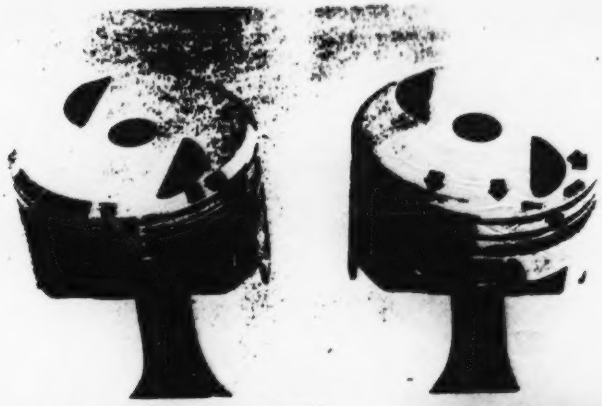
At rebuild time, measures can be instituted to prevent any future recession. Late-model heads can be installed that both lower compression and protect the exhaust valves via tough, "induction hardened" seats. Alternatively, hard insert seats can be retrofitted to older heads. Exhaust valve rotators should be discarded if they are of the type that cause the valve to rotate while in contact with the seat. In TRW tests, reducing the spring rate from 85 to 65 pounds reduced the wear rate 40 to 60 percent. When spring seat pressure was upped to 105 pounds, wear increased 60 percent. Unfortunately, such increased pressures are usually required when installing a hotter cam. There are also benefits in reduced exhaust valve seat angles. One report notes that "changing the valve seat angle from 45 degrees to 30 degrees reduced wear by 75 percent, making it comparable to wear rates using leaded fuel." Changing seat angles and/or discarding the rotators may prove detrimental if leaded fuel is ever again used in the engine, however.

And right now, low-lead gas remains available in .1 gram/gallon concentrations. While that's much less than the old days, when gas often contained 4 to 5 grams per gallon, it should provide sufficient protection for those engines still needing leaded gas. Current studies indicate that the "lead protection th[illegible]old value lies somewhere between .0[illegible].20 grams/gallon." Tests show that as little as .07 grams/gallon definitely eliminates most wear in most engines under normal operating conditions.

Unleaded-ship

Leaded gas is not without its drawbacks. It has been known to cause valve corrosion, weakening the metal and eventually forming a channel or gutter in the valve surface. The channel is rapidly enlarged by exhaust gases funneling through it, eventually resulting in valve failure. Flaking or crumbling of lead valve seat deposits also creates a gas path channel past the valve seat, once again resulting in erosion and rapid valve failure. Steeper valve seat angles, valve rotators, and high spring pressures minimize these tendencies but, as noted above, worsen unleaded fuel-induced valve seat recession.

More significantly, lead additives and their associated scavengers adversely affect engine wear, causing additional rust and corrosion. Engine oil life and effectiveness is reduced, while sludge formation and viscosity is increased. Unleaded gas virtually eliminates engine rusting while greatly reducing corrosive wear of bearings, cylinder bo[illegible] and piston rings. Taxi fleet tests hav[illegible]own a 70 to 150-percent reduction in piston ring and cylinder bore wear when un-



Sharp edges on piston top or in cylinder head combustion chambers cause detonation by acting as hot spots. Clay Smith Cams' George Striegel deburrs chambers and radiuses piston tops and valve reliefs to minimize these tendencies. Ultimately, chambers can be completely polished.

Water injection systems actuated by changes in engine vacuum, load, and/or rpm are widely available in the aftermarket. Spearco unit shown.

PING CONTROL
PING CONTROL

MSD "Ping Control" allows driver to advance or retard timing as required by merely turning a dashboard dial.

leaded gas replaced leaded fuel.

During low-speed operation, lead deposits form on spark plugs. Under high-temperature/high-acceleration conditions, the lead deposits become conductive, causing plug fouling. The deposits also corrode the electrode. Fleet tests show 35-percent fewer plug changes were required with unleaded fuel.

Lead scavengers cause severe exhaust system corrosion. With unleaded fuel, warm climate exhaust system replacement is virtually nonexistent. Even in colder environments, exhaust system replacement frequency with unleaded is significantly reduced.

Such unleaded benefits greatly reduce vehicle maintenance costs, and overwhelmingly outweigh any possible (though as we've seen, mainly theoretical) added costs imposed by shortened valve and valve seat life. If premature valve seat problems do occur, a future recurrence can be prevented by a head swap or modification of the existing heads.

Getting The Ping Out

With today's poor gas, many engines have problems with "pinging." Serious pinging (detonation) can damage or even destroy engine components, so it should not be tolerated. Assuming your financial resources permit it, the most effective anti-ping solution—because you won't sacrifice any power-making potential—is to increase the fuel's octane. Aftermarket octane boosting additives are widely available. Or, you can mix race gas or AvGas with pump gas to raise its octane. Because there's so little lead today in leaded automotive gas, it is no longer viable to mix pump leaded and unleaded; you will probably not realize any octane increase.

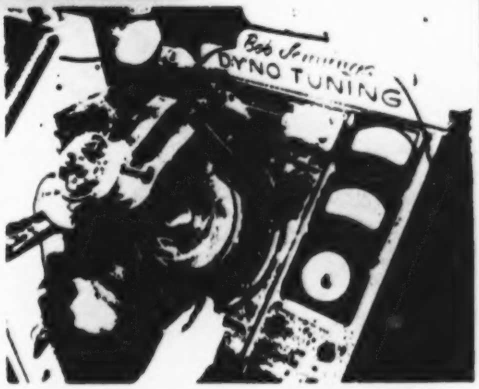
Can't afford those octane boosters? Then you'll have to settle for some sacrifice in power to eliminate the ping. Least on the power loss scale are water injection systems. Water injection lowers peak combustion temperatures, thus reducing pre-ignition and detonation tendencies. But water displaces some fuel, and the cooler temperatures mean that less energy or work is produced. Some of the lost "work" can be restored by injecting alcohol instead of water. Nitrous oxide injection for full-power runs is much better yet.

Finally, you can retard the timing. Some theoretical power potential may be lost, but at least the engine will live. The "free" way is simply to take out some initial timing; more sophisticated would be to go into the distributor and play with the advance curve. What you want to do is go back to a relatively slow, stock-type advance curve—the aftermarket kits usually quicken the curve, which only makes matters worse. Third, various aftermarket computers are now coming onto the market that enable the

To eliminate detonation on older high-compression motors, it may be necessary to retard the static timing and/or recurve the distributor. Curves need to be slowed down, not "hot rodded" up.

driver to retard or advance timing electrically, as necessary. MSD's "Ping Control" uses a dashboard-mounted manual dial to accomplish timing changes. MSD and Papile's Performance Products also offer pre-programmable computers that allow for virtually unlimited curve design flexibility.

When at last it's rebuilding time, the engine should be assembled to minimize ping possibilities. Lower the compression with different pistons or heads. Tests have shown that you only "lose" 10 to 15 horsepower per point of compression drop. But who says you had the horsepower in the first place? If you had to back off on the timing, go overrich on the carb, and/or are operating on the verge of detonation, the low-compression engine actually will produce much more real-world horsepower. Most engine builders recommend no more than 9 to 9.5:1 compression maximum (at sea level) these days. Part of the lost mechanical compression can be compensated for by installing a high-lift, short-duration camshaft that builds more effective cylinder pressure. OEM-type musclecar cams typically have relatively long duration in comparison to net lift, so they really don't work well in low-compression engines. A few engine builders, including Fordophile Kris Kaufman (Kaufman Products), are able to maintain 10 or even 10.5:1 compression ratios through incorporation of sophisticated proprietary dual-pattern asymmetric camshaft profiles and "high swirl" cylinder head and combustion chamber technology—but it is not a setup the average home-builder can duplicate with off-the-shelf parts in his backyard.



As a last resort, build the engine to better withstand detonation when it does occur. Most engine builders prefer premium tri-metal bearings and plasma-moly rings because they are better able to resist detonation, if it does occur. Premium hard-chrome stem and/or stainless steel valves are better able to resist the effects of heat and particle imbedding.

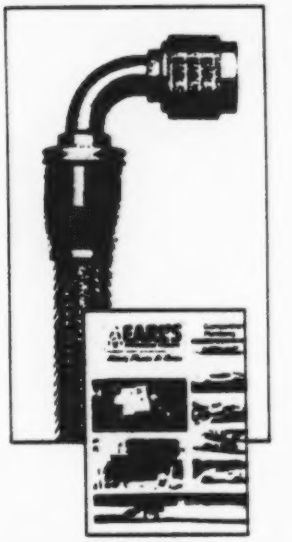
From all the foregoing, the main drawback of unleaded is its reduced real-world octane number. At the price of additional financial outlay, this can be overcome by using octane boosters or mixing unleaded with racing or aircraft fuel. Ultimately, the most practical solution is to rebuild the engine with a lower compression ratio.

BETTER QUALITY PRICE SELECTION SERVICE

BETTER BUY EARL'S

Nobody Plumbs it Better than Earl's...and nobody offers as complete a selection of every type of plumbing product and accessory.

There's a style for every plumbing application...choose from Swivel-Seal™ hose ends for competition, Auto-Fit™ hose ends for high performance, and Econ-o-Fit™, the original clamp hose ends for the look of performance plumbing.



Earl's product line also includes coolers, oil and fuel filters and specialty hardware, Spark-Flex™ ignition wires, adapter fittings and much more...it's all in the new 56 page full color catalog, just $4.00.

Nobody Plumbs It Better!

EARL'S
PERFORMANCE PRODUCTS
825 E. Sepulveda • Carson, CA 90746 • 213/830-1820

WIN POINTS IN THE OCTANE GAME WITH GASOLINE ADDITIVES

BOOSTER SHOT

By Marlan Davis

Have pings got you down? Has driving your car become a pain in the gas? Are your exhaust valves being "lead" astray? Well, as promised in the previous article, "Living With Unleaded," have we got some answers for you . . . and your favorite pet dinosaur. When it comes to the care and feeding of your old-fashioned high-compression musclecar, modern science has come up with a plethora of solutions to ensure it receives a healthy, high-octane diet. There are also products available to keep your exhaust valves from "sliding into recession." Many commercially available additives are designed to do both; some claim to do everything but walk on water. Unfortunately, nothing will ever replace good old tetra-ethyl lead's octane boosting and exhaust valve seat protection one-two punch. When researching this article, we sent questionnaires to major retail additive manufacturers; most would not divulge the specific contents of their products. Those we can actually classify are described in the appropriate sections below and in the chart on page 52.

Performance And Driveability Characteristics

Before getting down to specifics, a look at some of the factors affecting fuel performance in the real world is in order. As we've already covered, a fuel's anti-knock or anti-ping resistance is determined by its octane number. Any additional octane increase beyond that required to stop any ongoing engine knock or ping is a waste of money, and—according to some data—may even be counterproductive, causing a slight power *decrease*. Bottom line: Use fuel with octane quality only high enough to eliminate the ping.

Among the different ways to measure octane, *motor octane* is the most representative of real-world, full-throttle performance. *Research octane* numbers are artificially high and only indicate real-world "tip-in" ping tendencies. *R+M/2* octane is the way gas is rated at the pump, and is simply an average of the above two methods. Finally, aviation fuel is rated using a completely different system that has no relationship to the way automotive fuel is rated. Octane rating has nothing to do with exhaust valve seat recession characteristics.

For a street-driven car, octane is not the only factor influencing overall performance. Unlike a race car, the daily driver must start and run in the morning—every morning, even in Montana's sub-zero winters. Reid Vapor Pressure (RVP) is usually a good measure of a fuel's performance under different climatic conditions.

Under cold climatic conditions, a fuel with a high RVP will vaporize more easily in the carburetor and inlet manifold. Hence, the vehicle will start easier than if it was fueled with low RVP stock, which would tend to liquify and puddle in the manifold.

Under hot climatic conditions, a fuel with too high RVP causes vapor lock. Because of these potential problems, street pump gasoline RVP is seasonally adjusted—it usually runs 11 to 14 psi (at 100 degrees F.) in the winter, and falls to around 10 psi in the summer (by law in California, summer RVP must be less than 9). If your locale has a sudden bout of unseasonably hot or cold weather, cars often perform poorly—because the local gas station has stocked the "wrong" gas. Since vapor lock is disastrous for racers and airplanes, special gasolines produced for these activities have extremely low (compared to street gas) RVP's, as does several commercially available additives.

Another important term is *specific gravity*, which is the ratio of density of a particular fuel to water. If you are racing under a particular sanctioning body, your fuel mixture may have to meet certain arbitrary SG standards, as measured by the tech inspector's hydrometer. SG can also tell you a lot about whether a particular fuel will have a tendency to richen or lean-out your carb or fuel-injector. Final-

Illustration: Dean Foster

[redacted]

[redacted]

ly, there is *latent heat of evaporation*, which is the heat absorbed by a fuel during its change of phase from a liquid to a gas. The greater the latent heat of evaporation, the cooler the mixture, the more molecules can be crammed into a given area, and the greater the power-making potential.

With the terms defined, let's take a look at some of the common gasoline additives in use today.

BLENDING AVIATION AND RACE GAS WITH PUMP PREMIUM UNLEADED GASOLINE

	BLEND	RON	MON	R+M/2	SPECIFIC GRAVITY	APPROX. LEAD CONTENT (g. Pb/gal.)
100/130 AV-GAS (GREEN)	UNLEADED PREMIUM	96.8	85.8	91.3	0.7579	0
	75%-UP/25%-AvGas	99.2	90.3	94.8	0.7416	1
	50%-UP/50%-AvGas	100.9	94.4	97.6	0.7258	2
	25%-UP/75%-AvGas	101.3	99.8	100.6	0.7093	3
	AV-GAS 100/130	101.5	103.7	102.6	0.6926	4
NATIONALLY DISTRIBUTED RACE GAS	UNLEADED PREMIUM	96.8	85.8	91.3	0.7579	0
	75%-UP/25%-AvGas	101.8	91.1	96.4	0.7547	1
	50%-UP/50%-AvGas	104.9	96.1	100.0	0.7491	2
	25%-UP/75%-AvGas	109.2	100.1	104.6	0.7440	3
	RACE GAS	114.2	103.8	108.8	0.7408	4

100/130 AvGas has about the same motor octane number as typical race gas—yet is over a buck a gallon cheaper. Race gas has a much higher research octane number—but that doesn't help much in the way of real-world performance. All octane numbers derived using automotive test methods.

High-Octane Gas

As noted previously, tetra-ethyl lead is unsurpassed in its octane-boosting and exhaust valve seat recession-preventing ability. While street gas has almost no lead these days, race gas and aviation gas are chock-full of the good stuff. As shown in the chart, significant octane increases are obtainable by blending either race gas or 100/130 AvGas with pump premium unleaded. Compared to some of the more potent additives we'll be covering shortly, relatively large quantities of high-test are required, but—at least in the case of AvGas—it is relatively inexpensive. Unlike most other additives, there are no serious adverse driveability or maintainability consequences incurred by using high-octane gasoline. Compared to automotive gas, cold-weather driveability will be slightly impaired, due to the anti-vapor-lock (low RVP) characteristics of these fuels.

Note that the motor octane of 100/130 AvGas is about the same as typical race gas. AvGas is also much cheaper, and (since it's regulated by the government) is absolutely consistent from batch to batch. Due to AvGas' lower specific gravity, you will have to richen up the carburetor when running it in high percentages. That means gas mileage will be slightly lower than Race gas, which could be a factor in long-distance roundy-round competition.

Race gas manufacturers claim their product has a slightly higher energy content than AvGas, and thus offers a performance advantage in all-out competition. Any such differences are so slight it really isn't significant for any other racing besides NASCAR or Pro Stock.

Both AvGas and Race Gas are illegal for highway use, because road tax isn't collected, and they have too much lead.

PERFORMANCE CHARACTERISTICS OF COMMON ADDITIVES

NAME	OCTANE, PURE FORM			RVP	SPECIFIC GRAVITY	ESTIMATED PERFORMANCE IMPROVEMENT¹	AVAILABILITY	TYPICAL PRICE
	RESEARCH	MOTOR	R+M/2					
ANILINE	(Does not support combustion)				1.022	1 R+M/2 for each percent added up to 5%; see also graph	Not available to the public—requires DEA permit	
AVIATION GAS 100/130	102	104	103	4-6	0.69	See graph	Airport	$1.60/gal
BENZENE	106-110	95-100	100.5-105	3.2	0.88	Depends on base stock	Not available to the public—requires DEA permit	
ETHANOL	108			2.8	0.7893	See graph	Chemical supply house	55¢-$1.50/gal.²
ISOPROPYL ALCOHOL	112			1.3	0.7865	1.7 R+M/2 @ 10% concentration See also graph	Chemical supply house	$1.75-$2.95/gal.²
METHANOL	106-115	88-92	97-103.5	4.7-5	0.793	Unleaded regular: 2-3 R+M/2 @ 10% concentration Leaded regular: 1-2 R+M/2 @ 10% concentration See also graph	Chemical supply house, racing fuel distributor, aftermarket fuel additive	55¢-$1.50/gal. (in bulk)
MMT	(Does not support combustion)					Unleaded regular: 1.3 R+M/2 @ 0.1 g./gal. concentration Leaded premium: 0.7 R+M/2 @ 0.15 g./gal. concentration Unleaded premium: 1+ R+M/2 @ 0.1 g./gal. concentration	Retail aftermarket fuel additive	$6+/16 oz.
MTBE	116	101	108.5	7.8	0.7405	Unleaded regular: 1.5 R+M/2 @ 7% concentration Unleaded premium: 1.3 R+M/2 @ 7% concentration	Retail aftermarket fuel additive	$6+/16 oz.
RACE GAS	114	104	109	5-7	0.72-0.75	See graph	Racing fuel distributor	$2.50-$3/gal.
TERTIARY BUTYL ALCOHOL	113			2.7	0.789	.8 R+M/2 @ 7% concentration See also graph	Chemical supply house	$8.50/gal. in 5 gal. drum² $3.85/gal. in 55 gal. drum²
TOLUENE	120	109	114.5	1.0	0.87	Depends on base stock See also graph	Chemical supply house	$5.50/gal. in 5 gal. drum² $2.50/gal. in 55 gal. drum²
TRIPTANE	112	101	106.5		0.691	Depends on base stock—impossible to reliably refine, at present an "accidental" by-product		
XYLENE	118	115	116.5		0.86	Depends on base stock	Chemical supply house	$8.50/gal. in 5 gal. drum² $2.75/gal. in 55 gal. drum²

-16

¹Data, unless otherwise indicated, is for 92-octane premium unleaded. Unleaded regular is typically 87 octane (R + M/2). Premium leaded is typically 92 octane (R + M/2). Actual results will vary somewhat by base stock constituents.

²Priced at Dixco Diversified Chemical Sales, 104 E. South, Anaheim, CA 92805, (714) 535-4806 (January 1987)

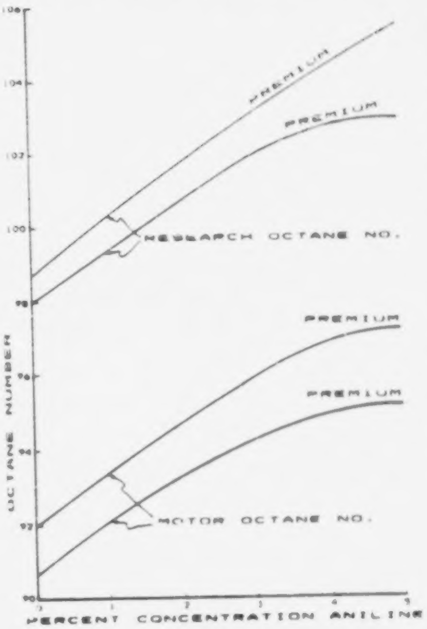
However, they should be technically legal if used as additives to pump gas. Av-Gas is available at airports; buy it by the 55-gallon drum "for off-highway use." Stay away from inferior 80/87 AvGas. "Low Lead" 100 AvGas has plenty of lead for any street car, but in blend has less octane-boosting ability than 115/130. If you're in the Air Force or Navy, you may have access to 115/145—that's the best gas in the world . . . 'nuff said!

Moving beyond pre-mixed gasoline blends, in some cases you can purchase the specific high-octane hydrocarbon components in "pure" unblended form from a chemical supply house. These include various aromatics and alkylates such as benzene, iso-octane, triptane, isodecane, cyclopentane, toluene, and xylene. Triptane has tremendous potential knock resistance, but with present technology it is impossible to reliably and economically refine, and any presence in blended gas is mainly by "accident." Benzene is not available to the general public without a DEA (Drug Enforcement Administration) permit, since it's used as a precursor in several illegal drugs. Racers are most familiar with toluene, which has been used with varying degrees of success to make "home brewed" race gas. It and xylene are available in bulk at the local chemical supply house. West Star Enterprise's "Power Plus" contains xylene among its active ingredients. All these hydrocarbons have a relatively heavy SG—so you'd have to lean out the carb. RVP is extremely low, resulting in daily driveability problems. Exact octane-boosting properties are hard to predict, since these heavy hydrocarbons are already a part of existing gasoline blends in varying degrees.

AFTERMARKET CANNED ADDITIVES

COMPANY NAME	PRODUCT NAME	CLAIMED FUNCTION
Champion Lubricants, Inc. 606 Laguna Richardson, TX 75080	QX-500 Fuel Lubricant	Lead substitute, reduces apparent octane requirement
First Brands Corp. 39 Old Ridgebury Rd. Danbury, CT 06817-0001	STP Lead Substitute	Lead substitute
Gold Eagle Co. 4400 S. Kildare Chicago, IL 60632	Quantum OI	Octane booster
	Quantum VS	Valve wear preventer, fuel system cleaner
	Quantum VS + OI	Combines above products' functions
Moroso Performance Products 80 Carter Dr. Guilford, CT 06437	Octane Booster	Octane booster (race)
	Octane Booster No. 2	Octane booster (street)
Octane Boost Corp. P.O. Box 271148 Dallas, TX 75227	104+ Octane Boost	Octane booster
	Super 104+ Octane Boost	Octane booster, high concentration
	104+ Real Lead	Exhaust valve seat protectant
Petrofoam International, Inc. P.O. Box 771447 Houston, TX 77215	No-Knox "G"	Octane booster, fuel system cleaner
	No-Knox "T"	Turbo motor version of above
Polar Molecular Corp. Vanguard Bldg., Suite 303 4801 Towne Centre Rd. Saginaw, MI 48604	DurAlt	Lead substitute, lubricant, combustion chamber cleaner, stabilizer, corrosion inhibitor
Radiator Specialty Co. P.O. Box 34689 Charlotte, NC 28234	Gunk Lead Substitute	Valve and upper cylinder wear preventer
	Gunk Octane Performance Booster	Deposit remover raises apparent octane
Sta-Lube Inc. 3039 Ana St., P.O. Box 5748 Compton, CA 90224-5748	Sim-U-Lead	Lead substitute/valve seat protector, apparent octane requirement reducer, fuel system cleaner
TK-7 Corp. 1300 NE 4th St. Oklahoma City, OK 73117	TK-7S Super Octane Power Booster	Lead substitute, valve wear preventor, upper cylinder lubricant, fuel system cleaner
	TK-7R "Big Daddy"	Racer version of above
Turbo USA Lubricants Corp. 12247 Lakeland Rd. Santa Fe Springs, CA 90670	Valve Saver	Lead substitute/valve wear preventor, carb cleaner
Unocal Corp. P.O. Box 7600 Los Angeles, CA 90051	Unocal 76 Valve Saver	Valve wear preventor, fuel system cleaner
VP Hydrocarbons 20846 Lamm Rd. Elmendorf, TX 78112	C-5 Fuel Additives	Octane booster/lead substitute, valve protector
West Star Enterprises, Inc. 9420 Reseda Blvd., Ste. 293 Northridge, CA 91324	Power Plus	Octane improver, fuel system cleaner
	Valve Guard	Lead substitute, valve lubricant

RESPONSE OF LEADED GASOLINE TO ADDITION OF ANILINE



Aniline is an effective octane booster in relatively high concentrations. However, due to health and law enforcement problems, it is being phased out. Response of unleaded fuel is similar.

Aniline

A highly effective octane booster, aniline was once used as the main ingredient in several aftermarket retail-level canned additive products, but because of its many undesirable characteristics, has today been mostly phased out. You could expect about a one octane increase for every percent aniline added to the gasoline base stock, up to a 5-percent concentration. Aniline removes combustion chamber deposits, so it also raises the "apparent octane." On the other hand, aniline is extremely toxic; it can be absorbed through the skin, enter the blood stream, and starve the body of oxygen. It'll eat right through paint and damage rubber seals, and can't be shipped by UPS. A drug precursor like toluene, a DEA-permit is required to buy it in bulk.

MMT

Otherwise known as methyl cyclopentadienyl manganese tricarbonyl (say that 10 times quickly—and flawlessly—and you get a free subscription), MMT was once hailed as the replacement for tetra-ethyl lead, since it both prevents exhaust valve seat recession and raises octane (although not as well as the real McCoy). But the EPA claims it fouls catalytic converters and increases hydrocarbon emissions; they have mandated its use only in leaded gas for pre-'75 cars in concentrations that do not exceed .1 g/gal. However, it is the principal component in several highly effective aftermarket retail-level canned additives, including Moroso Octane Booster and Octane Boost Corporation's 104+. For "off-road" use, it's just a matter of tipping the can. Be warned that in concentrations exceeding .2 g/gal., MMT produces a hard metal compound that may erode the engine. MMT also leaves a "rusty" residue in the combustion chamber and spark plugs, so don't be alarmed if your plugs don't "read" right.

Tetra-Ethyl Lead

If no other additive is as effective as the "real McCoy" tetra-ethyl lead, why not just dump in some of the good stuff? In pure, undiluted form, lead is so dangerous that we wouldn't recommend the average person procuring it—even if he

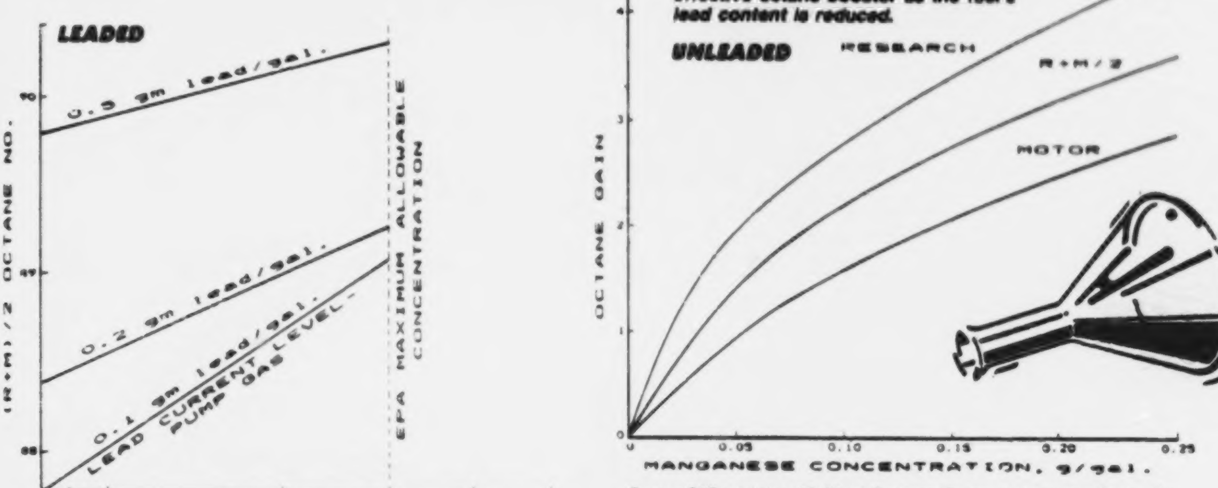
[redacted]

could (he can't). Several aftermarket manufacturers, including Octane Boost Corp. ("Real Lead") offer TEL in diluted, EPA-legal, .1 g/gal form. Adding a 32 oz. can to 22 gallons of leaded pump gas will double the blend's TEL concentration. That won't raise the octane much, but will provide iron-clad exhaust valve protection.

Oxygenates

MMT and lead boost octane, but they don't participate in the combustion process (although they do help the exhaust valves). The various hydrocarbons individually and in blend raise octane, and participate in combustion, but don't help valve life. We now come to oxygenates, which (while not helping the exhaust valve situation), not only participate in the combustion process while (in most cases) boosting octane, but also (as the name implies) carry some of their own oxygen with them. Hence, they offer the potential for increased power—either in pure form or in blend—beyond that offered by any hydrocarbon, MMT, or lead blend. Common oxygenates often added to base gasoline include various alcohol compounds, MTBE (methyl tertiary butyl ether), nitrous oxide, and nitroparaffins. Oxygenate specific gravity levels are generally higher than gas, but this is misleading because part of the added "weight" is supplied by the oxygen molecules; the net effect of adding an oxygenate is to greatly *lean-out* the overall air/fuel mixture. Major carburetor mods or even supplementary fuel metering systems are sometimes required when running high concentrations of oxygenates.

RESPONSE OF GASOLINE TO ADDITION OF MMT



As these graphs from Ethyl Corp. show, MMT becomes a proportionately more effective octane booster as the fuel's lead content is reduced.

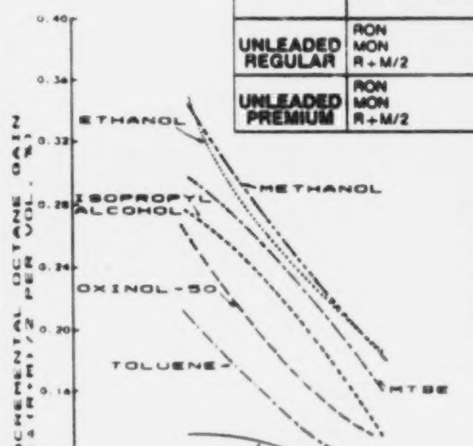
Source: SAE publication 85129, "A Technical Review of Automotive Racing Fuels," by Geoff J. Germane (Brigham Young University). Reprinted with permission. © 1985 Society of Automotive Engineers, Inc.

The *alcohols* include ethanol, methanol, isopropyl alcohol (drugstore or rubbing alcohol), and tertiary butyl alcohol (TBA). Relatively inexpensive, they provide a great bang for the octane buck and in pure form can boost horsepower up to 10 percent, but have all sorts of weird side effects. Methanol is the most common alcohol octane booster, but also has the greatest adverse results. Ethanol is as effective as methanol, but its side effects aren't as severe. While all the alcohols are to some extent corrosive and cause water to separate out of gas, these problems are much more severe with methanol, which has an unlimited ability to absorb water and will "eat" rubber, plastic, aluminum, and gas tank linings.

All the alcohols in pure form have low RVP numbers—so they have terrible cold-start characteristics. Fueled with 100-percent methanol, a car will not start below 60 degrees F. However, methanol and ethanol in blend with gasoline will increase the original gas RVP number as much as 3 and 1 psi, respectively, with the maximum effect occurring at approximately 3-percent alcohol concentration. Other alcohols in blend will lower the overall RVP. Even with methanol or ethanol-gas blends, cold-start driveability remains poor because of the significant cooling effects imparted by the alcohols' high latent heats of evaporation. The extremely high RVP of methanol-gas blends may also cause summer vapor

OXYGENATE/GASOLINE BLENDS

	OCTANE RATING	BASE GAS	BASE + 10% METHANOL	BASE + 10% ETHANOL
UNLEADED REGULAR	RON MON R+M/2	91.0 83.1 87.1	93.9 84.5 89.2	94.9 84.7 89.8
UNLEADED PREMIUM	RON MON R+M/2	97.7 86.5 92.1	100.2 88.1 94.2	100.7 88.4 94.6



Most oxygenates have excellent octane-enhancing properties. The graph from the Texaco Research Center shows that only TBA is less effective than toluene, a hydrocarbon normally used in blending high-octane gasoline. "Oxinol-50" is a refinery blend consisting of 50/50 methanol/TBA. Ethanol and methanol are the two most common blending oxygenates. The chart above shows the results of blending these oxygenates with unleaded regular and unleaded premium.

Source: SAE publication 861178, "The Properties and Performance of Modern Automotive Fuels," by P. Dorn, A.M. Mourao, and S. Herbstman (Texaco Research Center). Reprinted with permission. © 1986 Society of Automotive Engineers, Inc.

lock problems.

Extreme alcohol concentrations inhibit upper engine lubrication. On the other hand, high concentrations of methanol or ethanol added on a one-time "as needed" basis have been known to really clean up tailpipe emissions. Because of all the possible adverse effects, fuel engineers recommend limiting sustained-use gas-methanol concentration to no more than 10 percent for daily driven cars; no more than 15 percent for other alcohols. All alcohols are readily available in bulk form from chemical supply houses. Methanol can also be purchased from racing fuel distributors.

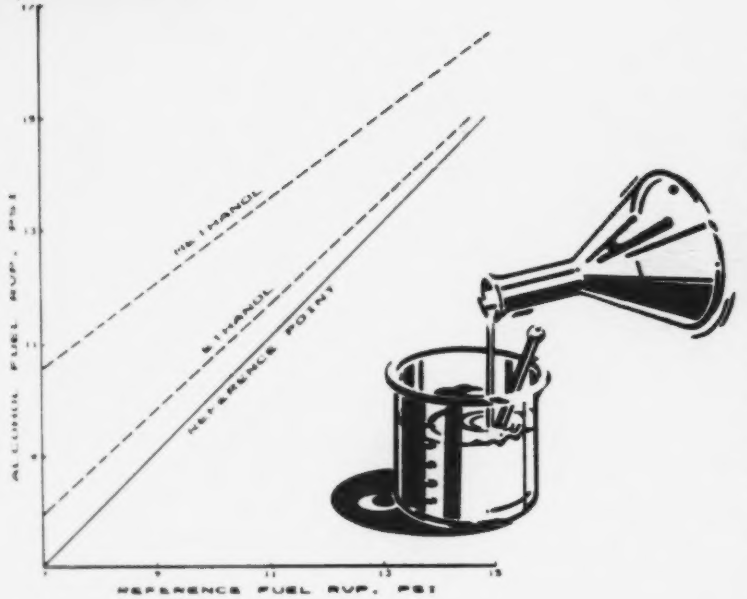
In pure form, ether has a terrible octane rating. But as *MTBE*, this oxygenate is a fair octane booster in concentrations up to 10 percent. Unlike the alcohols, it has no affinity for water. Unfortunately, it's hard to buy in bulk—you have to get it in moderately expensive retail-level quart cans. Petrofam's No-Knox octane booster is one aftermarket product known to contain MTBE.

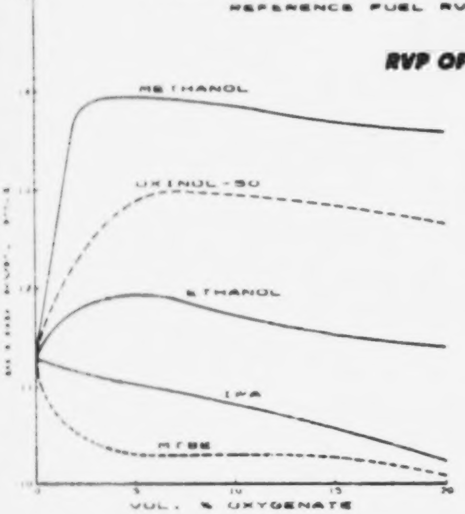
Nitrous oxide is known for its tremendous power increases. It requires its own separate storage bottle and fuel augmentation system. This can be an advantage, since it doesn't screw up the rest of the fuel system, and is used only when needed. Nitrous does not raise octane, nor lubricate exhaust valve seats.

Nitroparaffins (nitropropane, propylene oxide, peric acid, acetone) can also produce octane increases and power gains, but when used in high concentrations will severely lean-out the engine. Propylene oxide will produce about a 3-percent power gain at a 5-percent con-

ADDITIVES AT A GLANCE

ADDITIVE NAME	GOOD POINTS	BAD POINTS
ALCOHOL (methanol, ethanol, isopropyl alcohol, tertiary butyl alcohol)	Excellent octane boosting compounds As an oxygen-bearing compound, offers potential power gains Relatively inexpensive Reduces exhaust emissions (hydrocarbons and CO) Widely available commercially	Poor fuel economy Will cause water to seperate from gasoline; methanol has an unlimited ability to absorb water Methanol is highly corrosive, will "eat" ruber, plastic, aluminum, and steel Poor low temperature start and driveability characteristics Leans-out carburetor Extreme concentrations inhibit upper engine lubrication Methanol causes increased vapor lock when mixed with gas
ANILINE	Very good octane booster Increases "apparent octane rating" by cleaning deposits out of engine	Highly toxic, can be absorbed through skin and starve body of oxygen Eats ruber, plastic, and paint Fairly expensive Hard to ship Hard to purchase
HIGH-OCTANE HYDROCARBONS (benzene, toluene, xylene, triptane, etc.)	High-octane chemical gasoline molecule components Makes fuel more dense, increasing mileage potential Fully blendable with gasoline (since they are high-octane gasoline molecules) Not corrosive when mixed with gasoline	As an existing component of most gasoline, especially of unleaded gasoline, adding additional quantities may not significantly raise octane Need 10 percent or greater concentration to have significant affect Extremely low RVP results in severe cold-start problems when used in pure form
AVIATION GAS 100/130	High lead content, so both an extremely effective octane booster as well as an exhaust valve seat recession preventative Relatively inexpensive Wide availability at airports Absolutely consistent mix (regulated by FAA)	Illegal for highway use, so some airports may not sell to the general public Less dense than automotive or racing gas, so leans-out mixture Latent heat of evaporation not as high as race gas, so less cooling offset to incoming air/fuel charge Mileage decrease compared to race or pump gas Lower RVP and high volatility combine to offer cold-start problems under winter conditions
MMT (methyl cyclopentadienyl manganese tricarbonyl)	Very good octane improver Less toxic than aniline Prevents exhaust valve seat recession (but not as effective as lead) UPS-shippable Widely available at retail outlets	Plugs catalytic converters In concentrations greater than .2 g./gal., produces hard metal compound that may erode engine Increases hydrocarbon emissions Leaves "rusty" coating on spark plugs and in combustion chamber
MTBE (methyl tertiary butyl ether)	Fair octane improver in concentrations up to 10 percent No affinity for water, unlike pure ether or methanol	Relatively high percentage needed to significantly raise octane Fairly expensive
NITROPARAFFINS (nitropropane, propylene oxide, peric acid, acetone, etc.)	Oxygen and nitrogen-bearing compounds raise octane and add more power	Leans-out engine, negating many effects of octane boosting properties Corrosive—damage rubber and plastic
ORGANO-METAL LUBRICANTS	Prevent exhaust valve seat recession	Do not improve octane Not EPA-approved for unleaded gas
POLAR-ORGANIC LUBRICANTS	Prevent exhaust valve seat recession	Do not improve octane
AMINE DETERGENTS	Combustion chamber cleaners, carburetor cleaners Mild anti-rust and anti-icing properties	May increase induction system deposits as treatment levels approach 100 parts per million Does not improve octane, other than by removing built-up deposits
POLYMERIC DISPERSANTS	Combustion chamber cleaners, carburetor cleaners Stable at high temperatures, so can be used at high treatment levels to provide superior cleanliness throughout the engine (fluidizer oil may be required in concentrations over 400 parts per million)	Does not improve octane, other than by removing built-up deposits
TETRAETHYL LEAD	Most effective octane improver and exhaust valve seat recession inhibitor yet discovered Economical	Poison—being phased out by EPA mandate Not available to general public in effective octane-boosting concentrations Causes increased lifter, piston, and bore wear Causes exhaust system corrosion Not compatible with catalytic convertors or O_2 sensors
RACING GASOLINE	High lead content, so both an extremely effective octane booster as well as an exhaust valve seat recession preventative Specially formulated for automobiles Better mileage than AvGas Good latent heat of evaporation, so may impart positive cooling effect on incoming air/fuel mixture	Expensive Limited availability Brands produced by small refineries, may be inconsistent from batch to batch Lower RVP and high volatility combine to offer cold-start problems under winter conditions
NITROUS OXIDE	Oxygen-bearing compound that offers superior power increases Activated only when needed Excellent latent heat of evaporation, imparts dramatic cooling effect on incoming air/fuel mixture Nitrogen may serve as a detonation "buffer" Widely available at economic prices	Not an octane booster, does not lubricate exhaust valve seats Requires separate fuel enrichment system (usually supplied as part of total package) Requires separate storage area (bottle) Bottles must be refilled by dealer
WATER (INJECTED)	Suppresses detonation by cooling incoming air/fuel mixture Injection system activated only as needed Virtually free (after initial system purchase)	Does not support combustion, so may slightly reduce power Excessive water kills combustion process Requires separate container





RVP OF OXYGENATE/GASOLINE BLENDS

In pure form, most pure alcohols have a very low Reid Vapor Pressure. Yet, when mixed with gasoline, they increase RVP and volatility. Graph at left shows the effects of adding various concentrations to a base gas stock with initial RVP of 11. The graph above shows that the higher the RVP of the reference gasoline, the lesser the gain caused by alcohol.

Source: Same as Graph, pg. 53. Reprinted with permission. © 1986 SAE.

centration in gasoline, and has been known to get by fuel checks. TK-7 products contain nitroparaffins, among other active ingredients.

Protectants And Cleaners

By far the most common "genie in a bottle" retail products are the various additives designed to prevent exhaust valve seat recession and/or clean the combustion chamber. These in and of themselves usually have no octane-boosting properties, but may produce a so-called "apparent octane increase"—that is, by removing built-up combustion chamber deposits, they slightly reduce compression ratio and eliminate potential hot-spots. Typical retail additives may contain one or more of the following additives discussed below.

Additives primarily designed to eliminate harmful carburetor and combustion chamber deposits are classified as either conventional *amine detergents* or *polymeric dispersants*. As their name implies, detergents are basically cleansers. Dispersants not only cleanse, but are also said to have "the ability to disperse particulate matter in an extremely fine, harmless state, and keep it dispersed" until it is consumed in the combustion chamber. Polymeric dispersants also tend to be more stable at high temperatures, can be used in relatively high concentrations, help keep the PCV valve unplugged, and can even improve crankcase oil cleanliness. Conventional amine detergents may actually increase induction system deposits as treatment levels approach 100 parts per million, but on the other hand some amines and amine blends offer mild anti-rust and anti-icing properties. Aftermarket products known to contain detergents include the various "Quantum" products sold by Gold Eagle Co., Petrofam "No-Knox," and TK-7.

Products which can reduce exhaust valve seat recession include octane-boosting MMT (see above), mild concentrations of tetra-ethyl lead (see above), other forms of lead (which don't boost octane, but are less toxic than TEL), phosphorous, and various organometal and polar-organic lubricants. Polar Molecular's DurAlt is said to contain polar hydrocarbons and dispersants. Champion Lubricants' QX-500 contains "vacciaisocryptene." First Brand's STP and West Star's Valve Guard are said to contain sulfur, sodium, and nitrogen, among other components.

Additives may also contain corrosion inhibitors, fluidizer oils, solvents, and various "petroleum distillates," the latter of which is primarily a carrier for the other additives.

Finally, there is water—good old H_2O. Virtually free after the initial purchase price of an aftermarket water-injection unit is factored in, water lowers peak combustion chambers—which eliminates ping, but may also slightly reduce power (on the other hand, an engine that is operating in detonation is not making peak power anyway). Water also seems to keep combustion chambers clean.

Which Additive Is Right For Me?

That depends on whether octane boosting or exhaust valve seat protection is the most important. As we said in the previous article, recession is not a major problem, but the "octane blues" is. There are many ways to go on octane boosting additives. It boils down to convenience, availability, the intended vehicle use, climatic considerations, and price. Commercial retail level additives are widely available, but their actual concentration and even active ingredients are not usually disclosed. Bulk chemicals and high-performance gasolines are harder to obtain, but are often cheaper overall—and you know exactly what you're getting. When comparing different approaches, the following equation should help you to determine the most cost-effective approach:

$$\text{Octane boost/dollar} = \frac{(\text{Gallons of base stock} \times \text{cost/gal.}) + (\text{Gallons of additive} \times \text{cost/gal.})}{\text{Octane boost/gal.} \times \text{No. of gallons}}$$

Note that the amount of additive used per tank correspondingly reduces the amount of base stock used per tank, and that the effects of mixing several of the different additives mentioned above together may produce counter-productive results. Also, remember you need only the octane increase required to stop ping—anything more is a waste of money. Avoid becoming a victim of "More's Law!" Whatever route you choose, if you're willing to shell out the dough, you can ensure that the high-compression musclecar is one species that won't go the way of the passenger pigeon.

Special thanks to: Tim Wusz, Unocal Corp., and Dave West for technical assistance; Amy Hough and Ginger Joe (SAE/ Society of Automotive Engineers) for technical information, data search and permission to reprint selected graphs.

MODULE 06.02

PISTON ENGINE FUNDAMENTALS **INSTRUCTOR GUIDE**

COMPETENCY:
Identify two stroke cycle and four stroke cycle engines.

INSTRUCTIONAL OBJECTIVES:

The student will be able to:
1. Identify and state the purpose of the fundamental parts of internal combustion piston engines.
2. List the four events in the power production process in internal combustion piston engines.
3. Define compression ratio.
4. Define engine displacement.
5. Explain horsepower and torque.
6. Relate compression ratio and displacement to engine performance.
7. Explain the effects of heat on engine performance.
8. Identify and state the purpose of engine parts found only in four stroke cycle engines.
9. Explain the events in the four stroke cycle power production process.
10. Explain the method by which lubrication is achieved in four stroke cycle engines.
11. Identify and state the purpose of engine parts found only in two stroke cycle engines.
12. Explain the events in the two stroke cycle power production process.
13. Explain the method by which lubrication is achieved in two stroke cycle engines.
14. Differentiate the performance characteristics of two and four stroke cycle engines.
15. Describe crossflow cylinder scavenging.
16. Describe loop charged cylinder scavenging.
17. Explain the meaning of port timing.
18. Explain the role of exhaust tuning in the cycle engines.

LEARNING ACTIVITIES:
1. Participate in class lectures and discussions.
   (Objectives 1 - 18)
2. Study the information sheet "Two Cycle Engine Principles".
   (Objectives 1 - 18)
3. Read and study the information sheet "Mercury Marine Outboard Cylinder Charging".
   (Objectives 15, 16)
4. Read and study the information sheet "Theory of Operation of Two Cycle Engines".
   (Objectives 11 - 18)
5. Read the information sheet "Four Stroke Cycle Operation".
   (Objectives 8 - 10)

6. Complete the Terms Worksheet.
   (Objectives 1 - 18)
7. Complete the Two Stroke/Four Stroke Comparison Worksheet.
   (Objectives 1 - 18)
8. View the filmstrip "Basic Theory of Operation for the Two-stroke Cycle Engine".
   (Objectives 11 - 18)

EVALUATION/CHECK-OUT:

1. Turn in your Terms Worksheet.
2. Turn in your Two Stroke/Four Stroke Comparison Worksheet.
3. Take the Piston Engines multiple choice and score 70% or better.

RESOURCES:

LEARNING MATERIALS:

1. Copies of Information Sheet
   "Two Cycle Engine Principles"
   (master copy included in this guide)
   Excerpted from Mercury Marine Outboard Motor Service Training Notebook

2. Copies of Information Sheet
   "Mercury Marine Outboard Cylinder Charging"
   (master copy included in this guide)
   Excerpted from Mercury Marine Outboard Motor Service Training Notebook

3. Copies of Information Sheet
   "Theory of Operation of Two Cycle Engines"
   (master copy included in this guide)
   Excerpted from 1975 OMC Evinrude 2HP Service Manual, Powerhead section.

4. Copies of Information Sheet
   "Four Stroke Cycle Operation"
   (master copy included in this guide)

5. Copies of Worksheet
   "Two/Four Stroke Engine Comparison Worksheet"
   (master copy included in this guide)

6. Copies of Worksheet
   "Piston Engine Terms Worksheet"
   (master copy included in this guide)

7. Reference
   Two Stroke Tuner' Handbook

Gordon Jennings, 1973
ISBN 0-912656-41-7
HPBooks
Box 5367
Tucson, AZ 85703

EQUIPMENT:
(none used)

AUDIO VISUAL MATERIALS:

1. Filmstrip/Audio Cassette
   "Basic Theory of Operation for the Two-stroke
   Cycle Engine". P/N 59-9 OB
   OMC Training Department
   3145 Central Avenue - Desk C-613
   Waukegan, IL 60085
   (312) 689-5531

MODULE 06.02

PISTON ENGINE TERMS WORKSHEET

NAME________________________________ STUDENT NO.__________________

1. Crankshaft -

2. Power Cycle -

3. Two Stroke Cycle -

4. Four Stroke Cycle -

5. Torque -

6. Horsepower -

7. Scavenging -

8. Engine Displacement -

9. Compression Ratio -

10. Crankshaft Counterweight -

11. Intake & Exhaust Valves -

MODULE 06.02

12. Reed Valve -

13. Port Timing -

14. Cross-flow -

15. Loop Charging -

16. RPM -

17. Crankcase pressure -

18. Piston Exhaust Deflector -

19. Cylinder isolation -

20. Exhaust Tuning -

MODULE 06.02

Two/Four Stroke Cycle Engine Comparison Worksheet

NAME________________________________ STUDENT NO.________________

Two Stroke Features

Four Stroke Features

MODULE 06.02

Piston Engines Multiple Choice Test

NAME________________________________ **STUDENT NO.**________________

1. Four stroke cycle engines require _______ revolutions of the crankshaft to complete a power cycle.

   a. 1
   b. 2
   c. 3
   d. 4

2. Two stroke cycle engines require _______ revolutions of the crankshaft to complete a power cycle.

   a. 1
   b. 2
   c. 3
   d. 4

3. A stroke is

   a. one half of a compression cycle.
   b. one half of an intake cycle.
   c. a movement of the piston up or down in the cylinder.
   d. none of the above.

4. In four stroke cycle engines the intake and compression strokes happen

   a. during different crankshaft revolutions.
   b. when the exhaust port is blocked by the piston.
   c. twice per power cycle
   d. on the same crankshaft revolution.

5. In four stroke cycle engines the fuel/air mix is

   a. drawn into the cylinder by a partial vacuum created by the downward motion of the piston.
   b. pushed into the cylinder by positive crankcase pressure.
   c. gravity fed.

d. forced in by heat induction.

6. In four stroke cycle engines exhaust gasses are removed from the cylinder by

   a. being forced out by incoming fuel/air mix.
   b. pushed out by the piston.
   c. sucked out by the partial vacuum in the exhaust port.
   d. pushed out by the next exhaust cycle.

7. In two stroke cycle engines the intake and exhaust strokes happen

   a. during different crankshaft revolutions.
   b. when the exhaust port is blocked by the piston.
   c. are not separate strokes and both occur at the bottom of the power stroke.
   d. on the same crankshaft revolution.

8. In two stroke cycle engines the fuel/air mix is

   a. drawn into the cylinder by a partial vacuum created by the downward motion of the piston.
   b. pushed into the cylinder by positive crankcase pressure.
   c. gravity fed.
   d. forced in by heat induction.

9. In two stroke cycle engines the fuel/air charge in the crankcase is

   a. there by mistake because of blow-by.
   b. waiting to go through the intake valve.
   c. pressurized by the downward motion of the piston.
   d. damaging the lubricant that should reach the crankshaft.

10. Scavenging refers to

   a. fuel combustion.
   b. exhaust production.
   c. the flow of gasses into and out of the cylinder.
   d. the consumption of lubricant.

MODULE 06.02

11. In four stroke cycle engines the crankshaft bearings are lubricated by

    a. teflon in the bearing races.
    b. a thin film of fuel.
    c. oil which is in the crankcase along with the fuel.
    d. oil which is pumped and splashed around.

12. In two stroke cycle engines the crankshaft bearings are lubricated by

    a. teflon in the bearing races.
    b. a thin film of fuel.
    c. oil which is put in the crankcase along with the fuel.
    d. oil which is pumped and splashed around.

13. Torque is

    a. a unit of work.
    b. a force of rotation.
    c. measured in units of horsepower.
    d. used only for tightening nuts or bolts.

14. Torque is measured in units called

    a. RPM/horsepower.
    b. foot-pounds/Newton-meters.
    c. furlong-feet.
    d. inch-feet

15. Horsepower is

    a. the same as torque.
    b. a unit of work.
    c. not as important in two stroke engines as it is in four stroke engines.
    d. a rotational force.

16. In two stroke engines the intake port is ________ than the exhaust port.

    a. lower in the cylinder
    b. higher in the cylinder
    c. lower in the head
    d. higher in the head

17. Two types of scavenging in two stroke motors are

    a. loop and verti-port.
    b. verti-port and cross-flow
    c. cross-loop and power port
    d. cross-flow and loop

18. Compression ratio is

    a. cylinder pressure divided by crankcase pressure.
    b. cylinder pressure after compression stroke divided by cylinder pressure before compression stroke.
    c. varied by the fuel/air mix.
    d. used to determine scavenging methods.

19. Engine displacement is

    a. discovered at rebuild time by using a surface plate.
    b. the distance of the powerhead from the propshaft.
    c. the total volume of all engine cylinders including the combustion chamber in the cylinder head.
    d. cylinder head combustion chamber width time length.

20. In two stroke engines exhaust tuning

    a. is checked during synch and link procedures.
    b. is accomplished by adjusting reflected exhaust pulses.
    c. is not used in two stroke engines because of the absence of exhaust valves.
    d. is done to improve outboard out-of-the-hole performance by drilling an exhaust vent hole in the propeller according to the service bulletin.

MODULE 06.02

Piston Engines Multiple Choice Test

ANSWER KEY

1. B
2. A
3. C
4. D
5. A
6. B
7. C
8. B
9. C
10. C
11. D
12. C
13. B
14. B
15. B
16. A
17. D
18. B
19. C
20. B

MODULE 06.02

PISTON ENGINE INFORMATION SHEET

FOUR STROKE CYCLE OPERATION

Virtually all gasoline powered sterndrive and inboard marine engines are "four stroke cycle internal combustion reciprocating engines". (The latest and most well known exception being the U.S. Marine Force L-drive which is powered by an adapted two stroke outboard powerhead.) Let's break down the term "four stroke cycle internal combustion reciprocating engine" to get a clearer picture of just what it means.

Internal combustion obviously means that something is going to be burned inside something else. In this case gasoline fuel is going to be burned inside an engine cylinder to produce heat. It is this heat which causes the gasses inside the cylinder to expand and produce work which is measured in horsepower.

Somehow the work being done by the expanding gasses inside the cylinder needs to be captured. In piston engines the work of the expanding gasses is captured by the piston in the cylinder. The expanding gasses push on the piston which is forced to move back and forth or reciprocate in the cylinder. Most but not all of the energy from the push on the piston is transferred through the piston and piston rod to crankshaft then to the propeller to push the boat. Some of the energy is stored in the flywheel and crankshaft counterweights to move the piston in the cylinder for the purpose of preparing for the next power cycle.

**In piston engines a cycle is the complete sequence of events required to produce a single power pulse in a cylinder. A "four stroke cycle" is a power cycle which takes four strokes or movements of the piston and two revolutions of the crankshaft.
Surprisingly, only one of the strokes produces all the energy required for powering the other three strokes and the propeller!** Each one of these strokes has a name. Their names are: Intake stroke; Compression stroke; Power stroke; and Exhaust stroke.**

The intake and compression strokes both occur on the same revolution of the crankshaft. During the intake stroke the fuel/air mixture is drawn into the cylinder. There is an intake valve in the cylinder head which is timed to open when the piston begins to move down and create a partial vacuum in the cylinder. As the piston reaches the bottom of the intake stroke the intake valve closes and the compression stroke begins. The piston moving up in the cylinder compresses the fuel/air mixture so that it will produce the greatest amount of energy when ignited. The ignition spark is usually timed to occur somewhere before the top of the

compression stroke. This is to allow the combustion process to get a head start on the piston. Ideally, the piston will reach the top of its stroke when the most rapid and powerful part of the combustion process begins to take place.

When the combustion process is making the most power the piston starts down the cylinder and begins its power stroke and the crankshaft begins its second revolution of the cycle. During the power stroke the heat caused by the combustion of fuel greatly raises the temperature in the cylinder and the gasses found there expand with tremendous force to push the piston down. As the power stroke bottoms out the combustion process ends and the combustion by-products left in the cylinder must be cleared out. The exhaust stroke clears out the burnt gasses and begins when the piston completes the power stroke and heads back up to the top of the cylinder. The exhaust valve is timed to open when the exhaust stroke begins so that the piston pushes the exhaust gasses out of the cylinder. At the end of the exhaust stroke one power cycle has completed and the next is ready to begin with the following intake stroke.

So, a "four stroke cycle internal combustion reciprocating engine" is an engine which burns fuel internally to produce work, has a piston that moves back and forth in movements called strokes ,and takes four piston strokes, two up, two down , to turn the crankshaft two revolutions per power cycle.

** In single cylinder engines the energy required for the intake, compression and exhaust stroke is stored only in the flywheel and crankshaft counterweights. In multi-cylinder engines one or more pistons will always be on the power stroke providing the necessary energy.

NAME ______________________ STUDENT NO. ______________________

06.02 **PERFORMANCE CHECKLIST**

MODULE : PISTON ENGINE FUNDAMENTALS

COMPETENCY: 1. Recognize 2 and 4 stroke cycle engines
2. Identify basic 2 and 4 stroke engine parts

1. ☐ Turn in your Terms Worksheet.
2. ☐ Turn in your 2/4 Stroke Comparison Worksheet.
3. ☐ Take test.
4. ☐ Score
5. ☐
6. ☐
7. ☐
8. ☐
9. ☐
10. ☐
11. ☐
12. ☐
13. ☐
14. ☐
15. ☐

COMPETENCY ACHIEVED? ☐ YES ☐ NO

EXPLANATION:

OMC CYLINDER SCAVENGING INFORMATION SHEET

Cross-flow means that the fresh fuel mixture enters the combustion chamber through the intake (transfer) ports and flows across the top of the piston and out the exhaust ports, pushing the burned gases ahead of it. In order to efficiently clear the combustion chamber of the burned gases, a deflector dome type piston is necessary to deflect the charge up and around the combustion chamber. See Figure 5-2.

This model is a loop-scavenged engine and incorporates a flat piston dome. Three intake ports e slanted upward and facing each other. This .rectional effect forces the incoming charges to impinge on one another and flow upward and around the smooth dome shape in the combustion chamber, then down and out the exhaust ports on the adjacent side of the cylinder wall. The flow pattern of the incoming fresh fuel laden gases very effectively "drive" the burned exhaust gases from the cylinder. This results in a clean and powerful "charge" ready to be compressed and burned as the piston reaches the top of its stroke. See Figures 5-3 and 5-4.

Windows in the piston of this loop scavenged engine allow the fuel mixture to enter the cylinder from the crankcase through a smooth unbroken transfer passage, correctly designed for best efficiency.

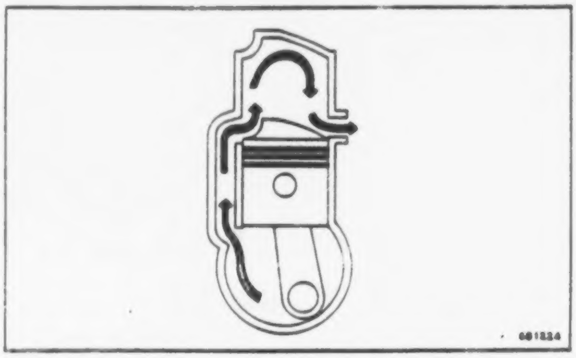


Figure 5-2. Cross-Flow Scavenging

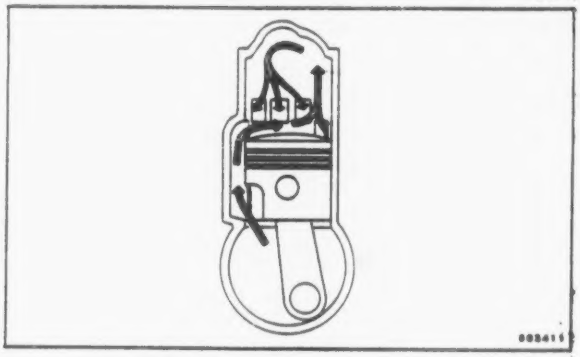


Figure 5-3. Loop Scavenging

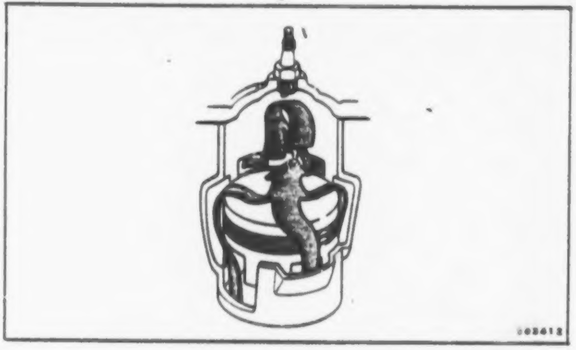


Figure 5-4. Loop Scavenged Cylinder

INFORMATION SHEET

"TWO STROKE ENGINE PRINCIPLES"

TWO-CYCLE ENGINE PRINCIPLE

FIG. 1
PRESSION

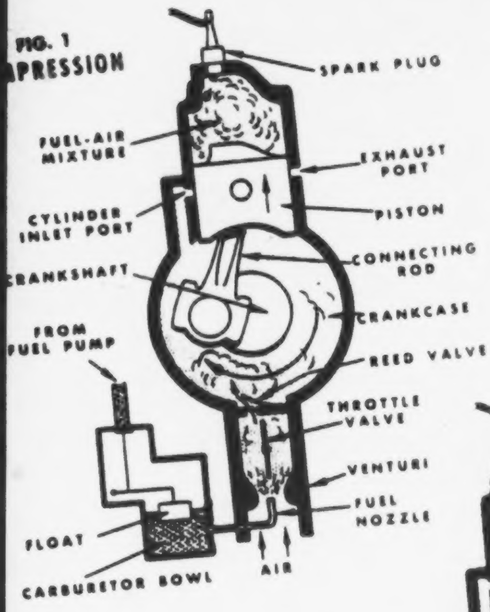

SPARK PLUG
FUEL-AIR MIXTURE
EXHAUST PORT
CYLINDER INLET PORT
PISTON
CONNECTING ROD
RANKSHAFT
CRANKCASE
FROM FUEL PUMP
REED VALVE
THROTTLE VALVE
VENTURI
FUEL NOZZLE
FLOAT
CARBURETOR BOWL
AIR

FIG. 3
EXHAUST

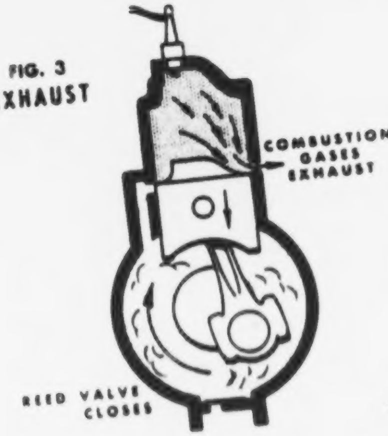

COMBUSTION GASES EXHAUST
REED VALVE CLOSES

FIG. 2
IGNITION

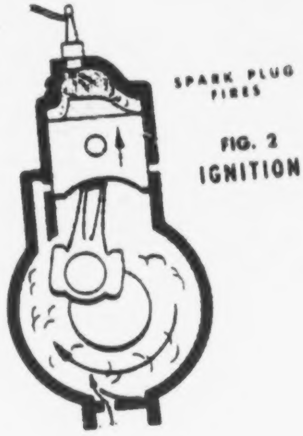
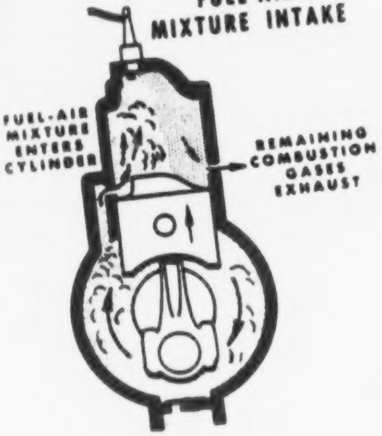
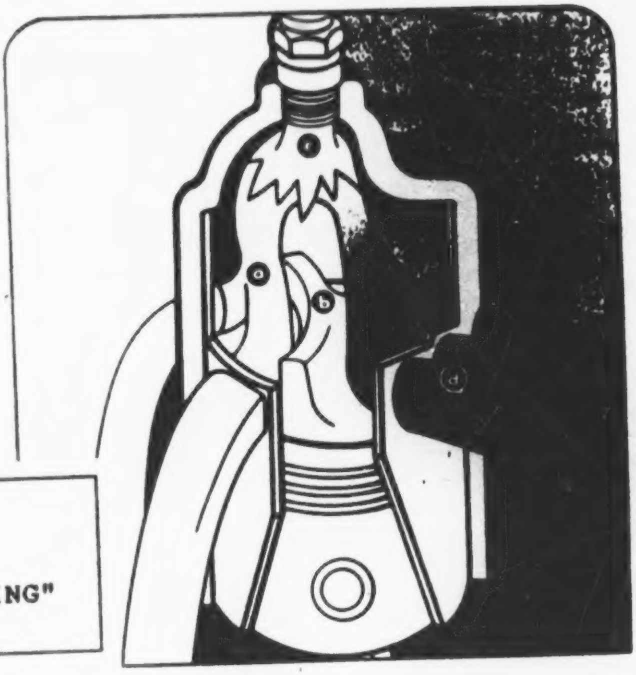

SPARK PLUG FIRES

FIG. 4
FUEL-AIR MIXTURE INTAKE


FUEL-AIR MIXTURE ENTERS CYLINDER
REMAINING COMBUSTION GASES EXHAUST

DIRECT CHARGE CYLINDER

During operation, a fresh fuel - air charge travels through a transfer passage in the engine block and enters the cylinder through two intake ports (A). The split fuel - air charge meets and is directed upward by a curved deflector on the piston (B). The converging fuel - air streams travel a precise course to the top of the combustion chamber (C) and then down the sloping side of the deflector effectively removing spent gases from the previous power stroke through four exhaust ports (D). The fresh induction mixture is thoroughly spread throughout the entire cylinder area, resulting in a clean and complete charge for the next power stroke.



INFORMATION SHEET

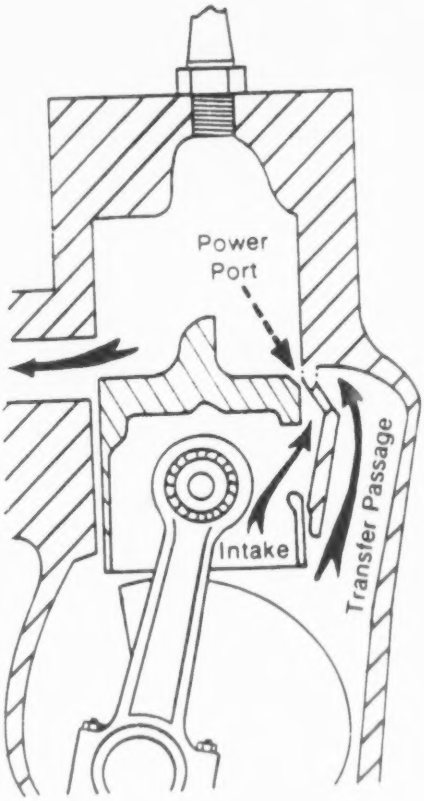
"MERCURY MARINE OUTBAORD CYLINDER CHARGING"

POWER PORTING

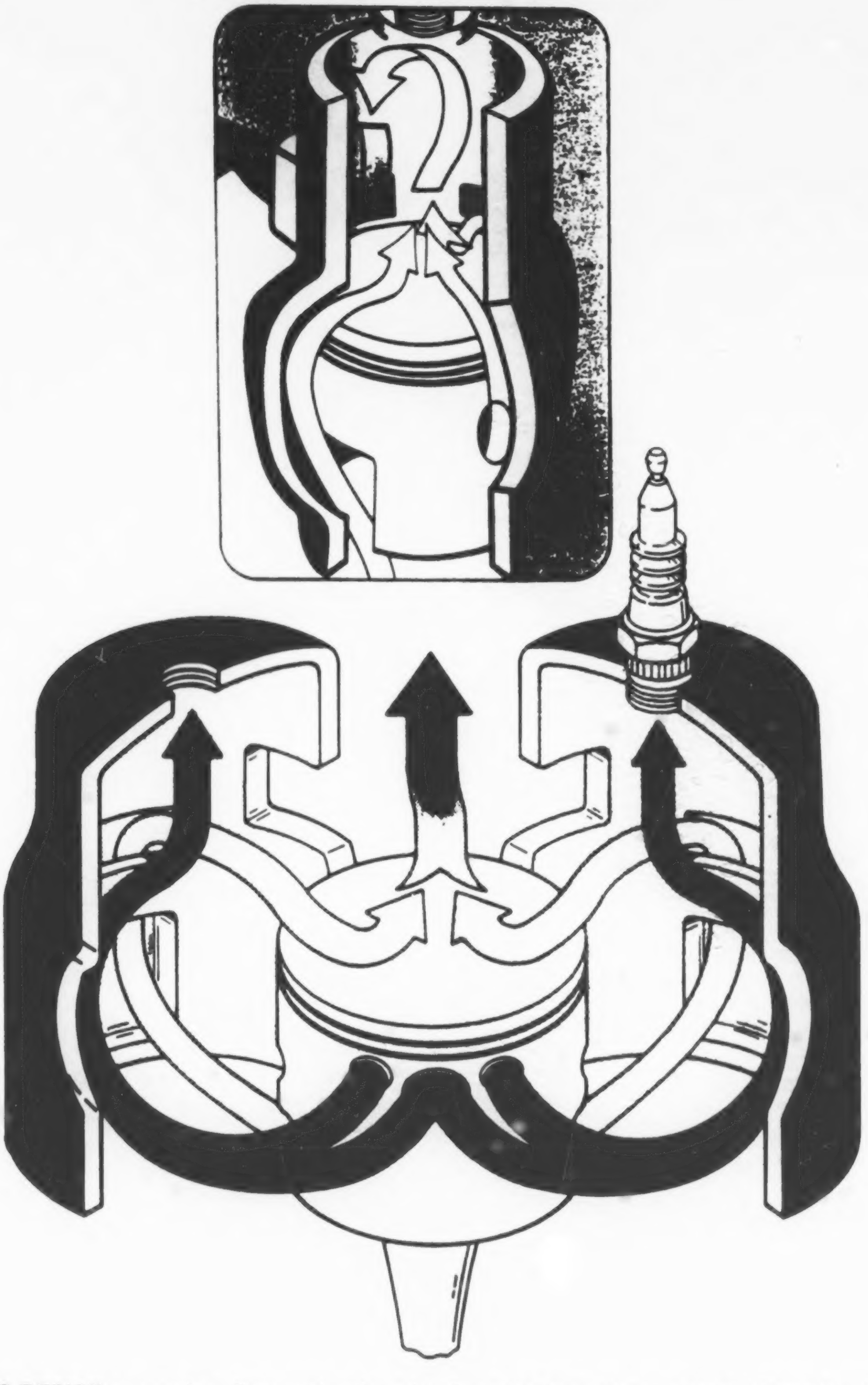
Power porting design incorporates a hole approximately 1" (round) in the piston skirt and a bevelled edge in the crown directly in front of the concave deflector, plus a slight modification of the internal transfer passage. The net effect is and additional source of fuel/ air mixture introduced to the combustion chamber during the charging sequence.

Benefits

Higher engine efficiency. More horsepower per cylinder. No increase in engine size and weight. When piston goes down, high pressurized mixture will pass through the power port to the chamber.



LOOP CHARGE SYSTEM



THE ARROWS DEPICT a complete flow cycle of the V - 6 models loop charge system. Three fuel/air streams enter the cylinder from opposing directions and converge below the spark plug. The confluent stream is compressed by the upward stroke of the piston. After ignition by the spark, waste gases are expelled through the cylinder exhaust port with the downward, power stroke of the piston.

INFORMATION SHEET

"THEORY OF OPERATION OF TWO CYCLE ENGINES"

The power head consists of one cylinder, piston, rod, crankshaft, and crankcase. The cylinder is horizontally mounted in a vertical plane and delivers one power impulse per crankshaft revolution. See Figure 5-1.

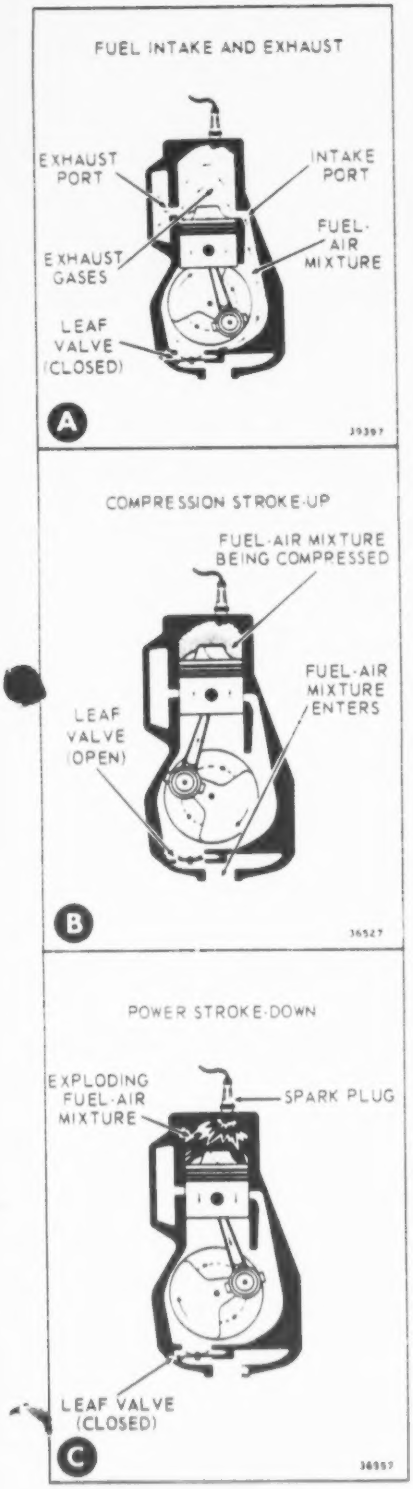


Figure 5-1. The Two Stroke Cycle

THEORY OF OPERATION

Two-cycle engines used on outboard motors require only two piston strokes - one up, one down, to effect a crankshaft revolution and to complete the exhaust-intake-compression-ignition sequence that produces power. In a two-cycle engine, ignition of the fuel-air mixture occurs as the piston reaches the top of each stroke. The explosion drives the piston downward. Toward the end of the downward stroke, ports which lead to the exhaust system are uncovered. The exhaust gases flow into these ports, thus reducing the pressure in the cylinder. At almost the same time, intake ports are opened. These ports connect with the crankcase where a fuel and air mixture has been induced by carburetion. The downward motion of the piston compresses this mixture in the crankcase and forces it through the intake ports into the cylinder. The inrushing charge of the fuel-air mixture helps in ejecting the last of the exhaust gases from the cylinder. See Figure 5-1, A, Fuel Intake and Exhaust.

As the piston begins its upstroke, it closes the intake and exhaust ports and begins to compress the fuel and air mixture trapped in the cylinder. The upward travel of the piston also reduces the pressure in the crankcase compartment. The resulting suction opens leaf valves which admit additional air and fuel from the carburetor into the crankcase, thus preparing the next cylinder charge. See Figure 5-1, B, Compression Stroke.

At the top of the piston stroke, the compressed fuel-air mixture is ignited by a timed spark and the cycle begins anew. In an outboard motor engine running at full throttle, this cycle may be repeated 4000 or more times every minute. See Figure 5-1, C, Power Stroke.

PISTON

The function of the piston in a two-cycle engine is to receive the force of combustion and to transfer it through the connecting rod to the crankshaft, and to control the flow of fuel vapor and exhaust gases by covering and uncovering the ports in the cylinder.

Since the piston, with the piston rings, receives the force of combustion in the cylinder head, it is necessary that both the piston and piston rings be properly fitted to form a seal between the piston head and cylinder wall. To retain maximum power within the cylinder head, the cylinder must be perfectly round and the piston rings correctly seated in their grooves.

CONNECTING ROD, CRANKSHAFT, AND BEARINGS

The connecting rod provides linkage between the piston and crankshaft. The force of combustion, applied to the piston in a reciprocating straight line thrust, is converted to rotating power at the crankshaft through the linkage of the connecting rod. The crankshaft is supported by a caged needle lower main bearing and a caged needle upper main bearing.

COOLING SYSTEM

The power head is water cooled. A water pump, driven by the driveshaft, forces water through channels in the power head. Heated water is discharged through the exhaust tube.

UNIT 7 -
INTRODUCTION TO STERN DRIVE SYSTEMS

MODULE 07.01

IDENTIFYING STERNDRIVE YEAR AND MODEL **INSTRUCTOR GUIDE**

COMPETENCY:

1. Recognize drive systems and engines and identify their model year.
2. Use parts manuals, service manuals, and service bulletins to obtain service information.

INSTRUCTIONAL OBJECTIVES:

The student will be able to:

1. Locate engine and drive system identification plates and/or markings.
2. Interpret engine and drive system identification plates and markings to obtain model and model year information.
3. Recognize and name the major sterndrive system components.
4. Locate parts manuals according to sterndrive model and/or serial number.
5. Interpret the information contained in parts manuals.
6. Locate service manuals according to sterndrive model and/or serial number.
7. Use service manuals to find sterndrive specifications and repair/maintenance procedures.
8. Locate sterndrive service bulletins according to model, year, and serial number.

LEARNING ACTIVITIES:

1. Participate in class lectures and discussions. (Objectives 1 - 8)
2. Practice locating service manuals, parts manuals, and service bulletins. Go into the shop and record the identification information found on several of the drive system and engine training aids. Use this information to locate the corresponding parts manual, service manual, and service bulletins. (Objectives 1, 2, 4, 6, 8)

EVALUATION/CHECK-OUT:

The instructor will evaluate your ability to locate and interpret sterndrive identification information as you practice on the training aids in the shop. Your ability to locate and use service literature will be evaluated as you perform disassembly, inspection, and reassembly tasks on training aids in the shop. Your performance will be recorded on the performance checklist.

RESOURCES:

LEARNING MATERIALS:

(none used)

MODULE 07.01

EQUIPMENT:

1. Manufacturer's service manuals, parts manuals, and service bulletins.

AUDIO VISUAL MATERIALS:

(none used)

NAME____________________________ **STUDENT NO.**____________________________

07.01

PERFORMANCE CHECKLIST

MODULE : IDENTIFYING STERNDRIVE YEAR AND MODEL

COMPETENCY: 1. Recognize drive systems and engines and identify their model and model year.

2. Use parts manuals, service manuals, and service bulletins to obtain service information.

1. ☐ Located identification plates and/or markings
2. ☐ Determined model and model year
3. ☐ Recognized and named sterndrive major components
4. ☐ Selected appropriate service manual
5. ☐ Located specifications and service procedures
6. ☐ Selected parts manual
7. ☐ Looked up parts information
8. ☐ Located service bulletins according to model and year
9. ☐
10. ☐
11. ☐
12. ☐
13. ☐

COMPETENCY ACHIEVED? ☐ **YES** ☐ **NO**

EXPLANATION:

MODULE 07.02

REPAIRING STERNDRIVE FUEL DELIVERY SYSTEMS INSTRUCTOR GUIDE

COMPETENCY:
Troubleshoot and repair sterndrive engine carburetors and fuel pumps.

INSTRUCTIONAL OBJECTIVES:

The student will be able to:
1. Recognize and name fuel pump components.
2. Explain fuel pump operation.
3. Remove and replace fuel strainers.
4. Test fuel pump function.
5. Remove and replace fuel pump.
6. Recognize types of sterndrive engine carburetors.
7. Recognize and name carburetor components.
8. State the differences between marine and automotive carburetors.
9. Explain the operation of sterndrive engine carburetors.
10. Remove, disassemble, clean, and inspect a carburetor.
11. Install carburetor rebuild kit components.
12. Reassemble, install, and adjust carburetor.

LEARNING ACTIVITIES:
1. Participate in class lectures and discussions. (Objectives 1 - 12)
2. Practice your fuel system skills on training aids in the shop. (Objectives 1 - 12)

EVALUATION/CHECK-OUT:
The instructor will observe your ability to recognize fuel system components and evaluate your ability to service them as you work on training aids in the shop. Your performance will be recorded on the performance checklist.

RESOURCES:

LEARNING MATERIALS:
1. Manufacturer's service manuals.

EQUIPMENT:
1. Student tool kits.
2. Sterndrive engine and fuel system training aids.

AUDIO VISUAL MATERIALS:
(none used)

NAME______________________ **STUDENT NO.**______________________

07.02 **PERFORMANCE CHECKLIST**

MODULE : REPAIRING STERNDRIVE FUEL DELIVERY SYSTEMS

COMPETENCY: Troubleshoot and repair sterndrive engine carburetors and fuel pumps

1. ☐ Recognized and named fuel pump components
2. ☐ Explained how fuel pump works
3. ☐ Located, removed, inspected, and replaces fuel strainer
4. ☐ Located fuel pump check procedure in service manual
5. ☐ Performed fuel pump check
6. ☐ Removed and replaced fuel pump
7. ☐ Recognized and named various sterndrive carburetors
8. ☐ Explained how sterndrive carburetors work
9. ☐ Recognized and named carburetor components
10. ☐ Explained differences in automotive and marine carbs
11. ☐ Disconnected and removed carburetor
12. ☐ Cleaned and inspected carburetor
13. ☐ Named components usually replaced during carb rebuild
14. ☐ Assembled and installed carburetor
15. ☐ Adjusted carburetors to specifications in service manual

COMPETENCY ACHIEVED? ☐ **YES** ☐ **NO**

EXPLANATION:

MODULE 07.03

REPAIRING STERNDRIVE CHARGING AND STARTING SYSTEMS **INSTRUCTOR GUIDE**

COMPETENCY:

1. Troubleshoot and repair sterndrive charging system.
2. Troubleshoot and repair sterndrive starting system.

INSTRUCTIONAL OBJECTIVES:

The student will be able to:

1. Look up battery size requirements according to engine model.
2. Recognize and name charging system components.
3. Explain charging system operation.
4. Perform a charging system output test.
5. Remove and replace an alternator and adjust belt to proper tension.
6. Remove and replace externally located rectifiers and regulators.
7. Recognize and name starting system components.
8. Explain operation of starting system.
9. Perform a cranking current test.
10. Explain effects of overcranking on starter motors.
11. Test starter solenoid relay.
12. Test starter solenoid.
13. Remove and replace a starter motor.

LEARNING ACTIVITIES:

1. Participate in class lectures and discussions.
   (Objectives 1 - 13)
2. Practice your ignition and charging system skills on training aids in the shop.
   (Objectives 1 - 13)

EVALUATION/CHECK-OUT:
The instructor will observe your ability to recognize charging and starting system components and evaluate your ability to test and service them as you work on training aids in the shop. Your performance will be recorded on the performance checklist.

RESOURCES:

LEARNING MATERIALS:

1. Manufacturer's service manuals.

EQUIPMENT:

1. Student tool kits.
2. Sterndrive engine and ignition system training aids.

AUDIO VISUAL MATERIALS:
(none used)

NAME____________________________ **STUDENT NO.**____________________________

07.03

PERFORMANCE CHECKLIST

MODULE : REPAIRING STERNDRIVE CHARGING AND STARTING SYSTEMS

COMPETENCY: Troubleshoot and repair sterndrive charging system.

1. ☐ Looked up battery size according to engine model
2. ☐ Recognized and named charging system components
3. ☐ Explained operation of alternator
4. ☐ Explained operation of rectifier/regulator
5. ☐ Looked up charging system test procedure in manual
6. ☐ Selected charging system test equipment
7. ☐ Set up and conducted charging system output test
8. ☐ Removed and replaced alternator
9. ☐ Adjusted tension on alternator belt
10. ☐ Removed and replaced external rectifier/regulator
11. ☐
12. ☐
13. ☐
14. ☐
15. ☐

COMPETENCY ACHIEVED? ☐ **YES** ☐ **NO**

EXPLANATION:

NAME________________________________ STUDENT NO.________________________________

PERFORMANCE CHECKLIST

MODULE : REPAIRING STERNDRIVE CHARGING AND STARTING SYSTEMS

COMPETENCY: Troubleshoot and repair sterndrive starting system.

1. ☐ Recognized and named starting system components
2. ☐ Explained operation of starting system
3. ☐ Looked up procedure for cranking current test
4. ☐ Selected test equipment for cranking current check
5. ☐ Set up and performed cranking current check
6. ☐ Differentiated outboard and sterndrive starter relays
7. ☐ Explained effects of overcranking on starter motor
8. ☐ Tested starter solenoid relay
9. ☐ Tested starter solenoid
10. ☐ Removed and replaced starter solenoid relay
11. ☐ Removed and replaced starter solenoid
12. ☐ Removed and replaced starter motor
13. ☐
14. ☐
15. ☐

COMPETENCY ACHIEVED? ☐ YES ☐ NO

EXPLANATION:

MODULE 07.04

REPAIRING STERNDRIVE IGNITION SYSTEMS **INSTRUCTOR GUIDE**

COMPETENCY:

Troubleshoot and repair sterndrive engine ignition systems.

INSTRUCTIONAL OBJECTIVES:

The student will be able to:

1. Install spark plugs correctly.
2. State the differences between sterndrive and outboard spark plugs.
3. Recognize and name types of sterndrive ignitions systems.
4. Recognize and name ignition system components.
5. Explain how standard battery ignition works.
6. Check distributor caps for carbon tracks, leakage, resistance, and other defects.
7. Test breaker points.
8. Test a condenser.
9. Test an ignition coil.
10. Test an ignition resistor.
11. Install an ignition tune-up kit.
12. Explain the meaning of the term dwell angle.
13. Align breaker points and set dwell angle.
14. Recognize and name distributor components.
15. Explain the operation of a centrifugal advance mechanism.
16. Remove, disassemble, and inspect a distributor.
17. Reassemble a distributor and install it on the correct cam shaft cycle.

LEARNING ACTIVITIES:

1. Participate in class lectures and discussions. (Objectives 1 - 17)
2. Practice your ignition system skills on training aids in the shop. (Objectives 1 - 17)

EVALUATION/CHECK-OUT:

The instructor will observe your ability to recognize ignition systems and their components and evaluate your ability to service them as you work on training aids in the shop. Your performance will be recorded on the performance checklist.

RESOURCES:

LEARNING MATERIALS:

1. Manufacturer's service manuals.

EQUIPMENT:

1. Student tool kits.

MODULE 07.04

2. Sterndrive engine and ignition system training aids.

AUDIO VISUAL MATERIALS:

(none used)

NAME________________________ STUDENT NO.________________________

07.04	PERFORMANCE CHECKLIST	1 of 2

MODULE : REPAIRING STERNDRIVE IGNITION SYSTEMS

COMPETENCY: Troubleshoot and repair sterndrive ignition systems.

1. ☐ Explained differences between I/O and O/B spark plugs
2. ☐ Installed spark plugs with correct torque setting
3. ☐ Recognized and named sterndrive ignition systems
4. ☐ Recognized and named ignition system components
5. ☐ Explained operation of standard battery ignition
6. ☐ Removed and inspected distributor cap
7. ☐ Removed and inspected breaker points
8. ☐ Checked breaker points resistance
9. ☐ Removed and tested condenser
10. ☐ Checked ignition coil for shorts
11. ☐ Looked up ignition coil resistance specification
12. ☐ Checked ignition coil resistance
13. ☐ Looked up ignition resistor specification
14. ☐ Checked resistance of ignition resistor
15. ☐ Installed tune-up kit in distributor of battery ignition

COMPETENCY ACHIEVED? ☐ YES ☐ NO

EXPLANATION:

NAME______________________________ **STUDENT NO.**______________________________

07.04 **PERFORMANCE CHECKLIST** contd. 2 of 2

MODULE : REPAIRING STERNDRIVE IGNITION SYSTEMS

COMPETENCY: Troubleshoot and repair sterndrive ignition systems.

16. ☐ Explained meaning of the term dwell angle
17. ☐ Aligned breaker point contacts
18. ☐ Set breaker point dwell angle
19. ☐ Recognized and named distributor components
20. ☐ Removed, disassembled, and inspected a distributor
21. ☐ Explained the operation of a centrifugal advancer
22. ☐ Reassembled distributor
23. ☐ Installed distributor on correct cam shaft cycle
24. ☐ Used a timing light to set ignition timing
25. ☐
26. ☐
27. ☐
28. ☐
29. ☐
30. ☐

COMPETENCY ACHIEVED? ☐ **YES** ☐ **NO**

EXPLANATION:

MODULE 07.05

REPAIRING STERNDRIVE ENGINES **INSTRUCTOR GUIDE**

COMPETENCY:

Remove, disassemble, inspect, and reassemble in-line and V8 sterndrive engines.

INSTRUCTIONAL OBJECTIVES:

The student will be able to:

1. Recognize and name sterndrive engine components.
2. Disconnect and remove a sterndrive engine.
3. Rig a sterndrive engine on an engine workstand.
4. Remove and install the following engine components:
    - electrical system
    - ignition system
    - fuel system
    - intake manifold
    - exhaust system
    - rocker arm covers and cylinder head(s)
    - rocker arms, push rods, and lifters
    - harmonic balancer
    - stator type alternator
    - water pump
    - oil pan and oil pump
    - timing gear cover and timing drive system
    - piston and rod
    - crankshaft main bearings and crankshaft
    - camshaft
5. Degrease cylinder block for inspection.
6. Look up specifications for and measure the following:
    - Crankshaft main bearing journals
    - Crankshaft rod bearing journals
    - Camshaft bearing journals and lobes
    - Piston, piston pin, and piston rod
    - Cylinder head valve guides
    - Cylinders
    - Piston ring end gap
7. Hone cylinders and prepare engine block for assembly.
8. Select and use assembly lubricants.
9. Select and use sealers.
10. Select crankshaft main bearings.
11. Use PlastiGauge to check crankshaft main bearing clearances.
12. Assemble pistons.
13. Torque cylinder head(s) using proper torque value and torque sequence.
14. Adjust intake and exhaust valves.
15. Retime distributor.

16. Install and align engine.
17. Perform pre-start checks and start engine
18. Explain engine break-in procedures

LEARNING ACTIVITIES:

1. Participate in class lectures and discussions. (Objectives 1 - 18)
2. Practice your engine disassembly and build-up skills on training engines in the shop. (Objectives 1 - 18)

EVALUATION/CHECK-OUT:

The instructor will observe your ability to recognize engine components and evaluate your ability to service them as you work on training engines in the shop. Your performance will be recorded on the performance checklist.

RESOURCES:

LEARNING MATERIALS:

1. Manufacturer's service manuals.

EQUIPMENT:

1. Student tool kits.
2. Sterndrive engine training aids.

AUDIO VISUAL MATERIALS:

(none used)

NAME____________________________ **STUDENT NO.**____________________________

07.05 **PERFORMANCE CHECKLIST** 1 of 3

MODULE : REPAIRING STERNDRIVE ENGINES

COMPETENCY: Remove, disassemble, inspect, and reassemble in-line and V8 sterndrive engines.

1. ☐ Recognized and named sterndrive engine components
2. ☐ Explained procedure for removing engine from boat
3. ☐ Rigged engine on workstand
4. ☐ Stripped engine of external components
5. ☐ Disassembled engine
6. ☐ De-greased and cleaned components for inspection

☐ Looked up specs for and measured the following:

7. ☐ Crankshaft main bearing journals
8. ☐ Crankshaft rod bearing journals
9. ☐ Camshaft bearing journals and lobes
10. ☐ Piston, piston pin, and piston rod
11. ☐ Valve guide clearance
12. ☐ Cylinders
13. ☐ Piston ring end gap
14. ☐ Explained cylinder honing procedure

COMPETENCY ACHIEVED? ☐ **YES** ☐ **NO**

EXPLANATION:

NAME______________________________ **STUDENT NO.**______________________________

07.05 **PERFORMANCE CHECKLIST** contd. 2 of 3

MODULE : REPAIRING STERNDRIVE ENGINES

COMPETENCY: Remove, disassemble, inspect, and reassemble in-line and V8 sterndrive engines.

15. ☐ Selected and applied assembly lubricants
16. ☐ Selected and applied sealers
17. ☐ Selected crankshaft main bearings
18. ☐ Use PlastiGauge to check crank main bearing clearance
19. ☐ Installed camshaft
20. ☐ Installed crankshaft and main bearings
21. ☐ Assembled pistons
22. ☐ Installed piston in cylinder, torqued rod cap
23. ☐ Installed lifters
24. ☐ Installed cylinder head
25. ☐ Torqued cylinder head to specification
26. ☐ Installed push rods and rocker arms
27. ☐ Installed intake manifold
28. ☐ Adjusted valves
29. ☐ Installed and re-timed distributor

COMPETENCY ACHIEVED? ☐ **YES** ☐ **NO**

EXPLANATION:

NAME______________________ **STUDENT NO.**______________________

07.05 **PERFORMANCE CHECKLIST** contd. 3 of 3

MODULE : REPAIRING STERNDRIVE ENGINES

COMPETENCY: Remove, disassemble, inspect, and reassemble in-line and V8 sterndrive engines.

30. ☐ Installed cooling system components
31. ☐ Installed fuel system components
32. ☐ Installed electrical system components
33. ☐ Installed ignition system components
34. ☐ Explained procedure for installing engine in boat
35. ☐ Performed engine pre-start check
36. ☐ Explained engine break-in procedure
37. ☐
38. ☐
39. ☐
40. ☐
41. ☐
42. ☐
43. ☐
44. ☐

COMPETENCY ACHIEVED? ☐ **YES** ☐ **NO**

EXPLANATION:

MODULE 07.06

REPAIRING STERNDRIVE TRIM AND TILT SYSTEMS INSTRUCTOR GUIDE

COMPETENCY:
Troubleshoot, disassemble, inspect, and repair sterndrive power trim and tilt system components.

INSTRUCTIONAL OBJECTIVES:

The student will be able to:
1. Recognize and name trim and tilt system components.
2. Explain the operation of the trim and tilt system.
3. Troubleshoot and repair trim and tilt system electrical components.
4. Test trim and tilt system hydraulic pump up and down pressure, trail-out valve pressure, and reverse lock valve pressure.
5. Test for hydraulic cylinder internal leaks.
6. Select hydraulic oil.
7. Operate manual release.
8. Disassemble/reassemble hydraulic pump, trim cylinders, and reverse lock valve.
9. Bleed air from hydraulic system.
10. Remove, install, and adjust trim limit switch
11. Remove, install, and adjust trim position indicator
12. Remove, install, and seal hydraulic hoses and fittings

LEARNING ACTIVITIES:
1. Participate in class lectures and discussions. (Objectives 1 - 12)
2. Practice your trim and tilt system skills on training aids in the shop. (Objectives 1 - 12)

EVALUATION/CHECK-OUT:
The instructor will observe your ability to recognize trim and tilt system components and evaluate your ability to service them as you work on training aids in the shop. Your performance will be recorded on the performance checklist.

RESOURCES:

LEARNING MATERIALS:
1. Manufacturer's service manuals.

EQUIPMENT:
1. Student tool kits.
2. Sterndrive trim and tilt system training aids.

AUDIO VISUAL MATERIALS:
(none used)

NAME____________________________ **STUDENT NO.**____________________________

07.06 **PERFORMANCE CHECKLIST** 1 of 2

MODULE : REPAIRING STERNDRIVE TRIM AND TILT SYSTEMS

COMPETENCY: Troubleshoot and repair sterndrive trim and tilt systems.

1. ☐ Recognized and named trim and tilt system components
2. ☐ Explained how trim and tilt system works
3. ☐ Tested trim and tilt control switch
4. ☐ Tested trim and tilt solenoids
5. ☐ Performed up and down pressure check
6. ☐ Pressure checked trail-out valve
7. ☐ Pressure checked reverse lock valve
8. ☐ Checked hydraulic cylinders for internal leaks
9. ☐ Selected hydraulic oil
10. ☐ Explained use of trim and tilt manual release
11. ☐ Disassembled/reassembled hydraulic pump
12. ☐ Disassembled/reassembled trim cylinder
13. ☐ Removed/reinstalled reverse lock valve
14. ☐ Installed hydraulic oil and bled air from system
15. ☐ Removed, sealed, and installed hydraulic hoses

COMPETENCY ACHIEVED? ☐ **YES** ☐ **NO**

EXPLANATION:

NAME______________________________ STUDENT NO.____________________________

MODULE : REPAIRING STERNDRIVE TRIM AND TILT SYSTEMS

COMPETENCY: Troubleshoot and repair sterndrive trim and tilt systems.

16. ☐ Removed/reinstalled trim limit switch
17. ☐ Adjusted trim limit switch
18. ☐ Removed/reinstalled trim position indicator
19. ☐ Calibrated trim position indicator
20. ☐
21. ☐
22. ☐
23. ☐
24. ☐
25. ☐
26. ☐
27. ☐
28. ☐
29. ☐
30. ☐

COMPETENCY ACHIEVED? ☐ **YES** ☐ **NO**

EXPLANATION:

MODULE 07.07

REPAIRING STERNDRIVE DRIVE SYSTEMS **INSTRUCTOR GUIDE**

COMPETENCY:

1. Repair sterndrive transom plate assembly.
2. Repair sterndrive gear housing.
3. Repair sterndrive drive shaft housing.

INSTRUCTIONAL OBJECTIVES:

The student will be able to:

1. Recognize and name transom plate components.
2. Remove drive unit from transom plate assembly.
3. Remove, inspect, and reinstall gimbal bearing and seals from transom assembly.
4. Select lubricant and apply to gimbal bearing.
5. Remove, inspect, and reinstall bell housing.
6. Remove, inspect, and reinstall gimbal housing.
7. Remove, inspect, and reinstall gimbal ring.
8. Remove gear housing from drive shaft housing.
9. Recognize and name gear housing components.
10. Remove, disassemble, clean, and inspect bearing carrier/reverse gear assembly.
11. Remove, disassemble, clean, and inspect drive shaft assembly.
12. Disassemble, clean, and inspect prop shaft/forward gear assembly.
13. Shim drive shaft/pinion gear, forward gear, and reverse gear for specified gear lash.
14. Torque pinion gear nut to specification.
15. Torque bearing carrier nut to specification.
16. Recognize and name drive shaft housing components.
17. Remove U-joint/drive gear assembly from drive shaft housing.
18. Take apart, clean, and inspect U-joint/drive gear assembly.
19. Renew U-joint bearings.
20. Take apart, clean and inspect drive shaft assembly.
21. Shim drive shaft for proper gear lash.
22. Assemble drive shaft housing.
23. Install gear housing on drive shaft housing.
24. Select lubricant and fill drive unit.
25. Adjust engine alignment for drive unit installation.
26. Select and apply bellows adhesive.
27. Install exhaust, U-joint, and shift cable bellows and locate clamps properly.
28. Install shift cable.
29. Install drive unit on transom plate assembly.
30. Adjust shift cables.

LEARNING ACTIVITIES:

1. Participate in class lectures and discussions.

(Objectives 1 - 30)

2. Practice your drive system skills on training aids in the shop. (Objectives 1 - 12)

EVALUATION/CHECK-OUT:

The instructor will observe your ability to recognize drive system components and evaluate your ability to service them as you work on training aids in the shop. Your performance will be recorded on the performance checklist.

RESOURCES:

LEARNING MATERIALS:

1. Manufacturer's service manuals.

EQUIPMENT:

1. Student tool kits.
2. Sterndrive drive system training aids.

AUDIO VISUAL MATERIALS:

(none used)

NAME____________________________ **STUDENT NO.**____________________________

07.07 **PERFORMANCE CHECKLIST**

MODULE : REPAIRING STERNDRIVE DRIVE SYSTEMS

COMPETENCY: Repair sterndrive transom plate assembly.

1. ☐ Recognized and named transom plate components
2. ☐ Removed drive unit from transom assembly
3. ☐ Removed and reinstalled gimbal bearing
4. ☐ Selected lubricant and lubricated gimbal bearing
5. ☐ Removed and reinstalled bell housing
6. ☐ Removed and reinstalled gimbal ring
7. ☐ Removed and reinstalled gimbal housing
8. ☐ Explained transom plate maintenance procedure
9. ☐
10. ☐
11. ☐
12. ☐
13. ☐
14. ☐
15. ☐

COMPETENCY ACHIEVED? ☐ **YES** ☐ **NO**

EXPLANATION:

NAME______________________________ STUDENT NO.______________________________

07.07 **PERFORMANCE CHECKLIST**

MODULE : REPAIRING STERNDRIVE DRIVE SYSTEMS

COMPETENCY: Repair sterndrive gear housing.

1. ☐ Recognized and named gear housing components
2. ☐ Removed gear housing from drive shaft housing
3. ☐ Removed bearing carrier/reverse gear assembly
4. ☐ Removed gear housing drive shaft assembly
5. ☐ Removed prop shaft/forward gear assembly
6. ☐ Disassembled/reassembled drive shaft/forward gear parts
7. ☐ Disassembled/reassembled bearing carrier/reverse gear
8. ☐ Shimmed drive shaft/pinion gear
9. ☐ Shimmed forward gear
10. ☐ Shimmed reverse gear
11. ☐ Torqued pinion nut to required specification
12. ☐ Installed bearing carrier and torqued nut to spec.
13. ☐
14. ☐
15. ☐

COMPETENCY ACHIEVED? ☐ **YES** ☐ **NO**

EXPLANATION:

NAME____________________________ **STUDENT NO.**____________________________

07.07 **PERFORMANCE CHECKLIST**

MODULE : REPAIRING STERNDRIVE DRIVE SYSTEMS

COMPETENCY: Repair sterndrive drive shaft housing

1. ☐ Recognized and named drive shaft housing components
2. ☐ Removed U-joint/drive gear assembly
3. ☐ Disassembled/reassembled U-joint/drive gear parts
4. ☐ Removed and replaced U-joint bearings
5. ☐ Disassembled/reassembled drive shaft
6. ☐ Shimmed drive shaft
7. ☐ Assembled drive shaft housing
8. ☐ Installed gear housing on drive shaft housing
9. ☐ Selected lubricant and filled drive unit
10. ☐ Selected and applied bellows adhesive
11. ☐ Installed U-joint, exhaust, and shift cable bellows
12. ☐ Located bellows clamps properly
13. ☐ Checked and adjusted engine alignment
14. ☐ Installed drive unit on transom plate assembly
15. ☐ Adjusted shift cables

COMPETENCY ACHIEVED? ☐ **YES** ☐ **NO**

EXPLANATION:

UNIT 8 - LUBRICANTS

MODULE 08.01

IDENTIFYING AND SELECTING LUBRICANTS INSTRUCTOR GUIDE

COMPETENCY:
Select and apply lubricants for the operation, repair, and maintenance of boats and engines.

INSTRUCTIONAL OBJECTIVES:

The student will be able to:

1. Describe the effect of friction on engine parts.
2. Explain how lubricants protect engine parts against the forces of friction, heat, and corrosion.
3. Explain the term oil viscosity.
4. State the properties which an oil must possess to be used in a two cycle gasoline engine.
5. Explain the reasons for using only those oils sold by major outboard engine manufacturers.
6. Calculate the amount of 50:1 engine oil required to achieve a 100:1, 50:1, and a 25:1 fuel to oil ratio for the following quantities of gasoline:
    - 1 gal
    - 6 gal
    - 10 gal
    - 12 gal
    - 20 gal
    - 100 gal
7. State the properties that a lubricant must possess to be used as a marine gear lubricant.
8. Describe the properties of grease.
9. Identify the uses for the following types of grease in repairing and maintaining boats and engines:
    - general purpose
    - extreme pressure
    - "moly" lube
    - petroleum jelly
    - wheel bearing
    - anti-corrosion
10. State the properties that a lubricant must possess in order to be used in hydraulic systems.

LEARNING ACTIVITIES:

1. Participate in class lectures and discussions. (Objectives 1 - 10)
2. Read "Lubricants and Hydraulic Fluids: what they do and why" (Objectives 1 - 3, 7, 8, 10)
3. Select a service manual then locate and read the information in the

Maintenance section on required lubricants and their application. (Objective 9)

4. Go to the area in the shop where the lubricants are stored. Observe the various types that are found there and the containers in which they are stored.
   (Objective 9)
5. Complete the Outboard Engine Oil worksheet.
   (Objective 6)

EVALUATION/CHECK-OUT:

1. Take the Lubricants multiple choice test.
2. The instructor will observe your selection and use of lubricants as you perform repair and maintenance tasks in the shop.
3. Turn in you Outboard Engine Oil worksheet.

RESOURCES:

LEARNING MATERIALS:

1. Reference
   "Lubricants and Hydraulic Fluids: what they do and why"
   Form 8417. Revised 2/89.
   Copies provided by Sales Engineering Dept. of
   Kendall Refining Company Division of Witco Corporation
   Bradford, PA 16701
   (814) 368-6111

2. Worksheet
   Outboard Engine Oil Worksheet.
   (Master copy included in this guide.)

3. Lubricants multiple choice test.
   (Master copy included in this guide)

EQUIPMENT:

1. Examples of lubricants in their containers. These should be the products which will normally be found in the marine service facility.
2. Copies of various service manuals.

AUDIO VISUAL MATERIALS:

(none used)

MODULE 08.01

Outboard Engine Oil Worksheet

NAME__________________________________ STUDENT NO.__________________

For each of the following fuel to oil ratios calculate the number of ounces of 50:1 oil required for the given amounts of gasoline.

RATIO = 50:1

gallons fuel   ounces oil

1..................

6..................

10.................

12.................

20.................

100................

RATIO = 25:1

gallons fuel   ounces oil

1..................

6..................

10.................

12.................

20.................

100................

RATIO = 100:1

gallons fuel   ounces oil

1..................

6..................

10..................

12..................

20..................

100................

MODULE 08.01

Lubricants Multiple Choice Test

NAME________________________________ STUDENT NO.__________________

1. The four primary purposes of a motor oil are to lubricate, to seal, to cool, and to clean.

    a. True
    b. False
    c. not to cool
    d. not to seal

2. The most important quality of a motor oil is its ability to

    a. fight corrosion.
    b. stick to metal surfaces.
    c. resist change due to temperature.
    d. clean up after itself.

3. In an outboard engine motor oil is used to

    a. help seal the cylinder around the piston.
    b. help seal reed valves.
    c. both a and b
    d. none of the above

4. Viscosity is a measure of an oil's ability to

    a. fight corrosion.
    b. resist foaming.
    c. resist combustion.
    d. resist change due to temperature and operating speed.

5. The most important feature of an outboard motor oil are its ability to

    a. lubricate and burn without leaving ash.
    b. condense in the crankcase to lube bearings.
    c. lubricate and seal labyrinth seals
    d. burn without making smoke.

6. The most important feature of a hydraulic oil is it ability to

   a. seal the high pressure hydraulic system.
   b. resist compression.
   c. not react with rubber pump seals.
   d. compress at low heat.

7. Besides lubrication the next most important function of gear lubricant is to

   a. keep water away from gears.
   b. resist combining with water.
   c. carry heat away from critical points.
   d. act as hydraulic fluid in hydraulic assist gearcases.

8. The ability of gear lubes to hold up under the extreme pressures of the operation of hypoid gears as found in outboard gearcases is achieved by

   a. heavy refining.
   b. tough testing standards.
   c. high viscosity.
   d. putting extreme pressure additives into the gear lube.

9. The most important feature of grease is its

   a. viscosity
   b. fiber content.
   c. resistance to water.
   d. ability to stick to metal parts.

10. The white general purpose grease found in the marine shop for light duty lubricating is

    a. "moly" lube.
    b. anti-corrosion grease.
    c. lithium grease.
    d. wheel bearing grease.

11. The best type of grease to use in extreme pressure applications is

    a. "moly" lube.
    b. anti-corrosion grease.
    c. lithium grease.
    d. wheel bearing grease.

12. The most important feature of trailer wheel bearing grease is its ability to resist

    a. being thrown out of the bearing while it spins.
    b. being washed out of the bearing at the boat ramp.
    c. heavy breaking.
    d. needle bearing corrosion.

13. Friction is caused by

    a. heat.
    b. two imperfect surfaces rubbing on each other.
    c. bad oil.
    d. static electricity

14. Oil prevents friction by

    a. removing heat.
    b. preventing corrosion.
    c. providing a thin film for parts to ride on.
    d. none of the above.

15. ___________ is the biggest factor in reducing the useful life of a lubricating oil.

    a. friction
    b. heat
    c. contamination
    d. loss of additives

MODULE 08.01

Multiple Choice Test

ANSWER KEY

1. A
2. B
3. C
4. D
5. A
6. B
7. C
8. D
9. D
10. C
11. A
12. A
13. B
14. C
15. C

NAME______________________________ **STUDENT NO.**______________________________

08.01

PERFORMANCE CHECKLIST

MODULE : Using Lubricants

COMPETENCY: Select and apply lubricants for the operation, repair or maintenance of boats or engines.

1. ☐ Turn in Outboard Engine Oil worksheet.
2. ☐ Take Lubricants multiple choice test.
3. ☐ Score.
4. ☐ Selected and applied gear lubricants.
5. ☐ Selected and applied outboard midsection lubricants.
6. ☐ Selected and mixed outboard engine oil.
7. ☐ Selected an applied general powerhead lubricants.
8. ☐ Selected and applied trim/tilt system fluid.
9. ☐
10. ☐
11. ☐
12. ☐
13. ☐
14. ☐
15. ☐

COMPETENCY ACHIEVED? ☐ **YES** ☐ **NO**

EXPLANATION:

UNIT 9 - ELECTRICITY

MODULE 09.01

UNDERSTANDING ELECTRICITY **INSTRUCTOR GUIDE**

COMPETENCY:

1. Explain basic principles of electricity.
2. Identify electrical devices.
3. Read and interpret wiring diagrams.
4. Use a VOM/Multimeter to measure voltage, current, and resistance.

INSTRUCTIONAL OBJECTIVES:

The student will be able to:

1. Explain the concept of the atom.
2. Identify the atomic particle which makes up electricity.
3. Explain the meaning of the terms charge and electrical polarity.
4. Define the term circuit.
5. Explain the meaning of the term ground.
6. Identify the common measurable properties of electricity and the units used to measure them.
7. State the difference between alternating and direct current.
8. Explain the concept of electrical resistance and identify its unit of measurement.
9. Identify two common sources of electricity.
10. Explain basic magnetic induction.
11. Describe how batteries work.
12. Use a VOM/Multimeter to measure voltage, current, and resistance.
13. Identify types of mechanical switches.
14. Explain the meaning of the term semiconductor.
15. Identify basic semiconductor devices and their functions.
16. Identify capacitors.
17. Explain the function of a capacitor.
18. Identify standard electrical symbols.
19. Interpret the function of circuits from their drawings.
20. Draw basic circuit diagrams.

LEARNING ACTIVITIES:

1. Participate in class lectures and discussions.
   (Objectives 1 - 20)
2. Read Chapter 1 in "Your Boat's Electrical System"
   (Objectives 1 - 12)
3. You will be given the opportunity to use a VOM/Multimeter to practice measuring voltage, current, and resistance in circuits on a training aid.
   (Objectives 4, 6 - 8, 12)

308

MODULE 09.01

EVALUATION/CHECK-OUT:

1. Take the Understanding Electricity multiple choice test and score 70% or better.
2. The instructor will observe your ability to use the VOM/Multimeter to make measurements on the training aid. Your performance will be recorded on the performance checklist.

RESOURCES:

LEARNING MATERIALS:

1. Reference

"Your Boat's Electrical System", 2nd revised edition
Conrad Miller, Elbert S. Maloney
The Hearst Corporation
1988, ISBN 0-688-08132-0

EQUIPMENT:

1. VOM/Multimeter Training aid.
   (This training aid built according to the circuit diagram included with this module.)

2. VOM/Multimeter

AUDIO VISUAL MATERIALS:

(none used)

MODULE 09.01

Understanding Electricity Multiple Choice Test

NAME____________________________________ **STUDENT NO.**___________________

1. All matter is made up of

   a. material
   b. photons
   c. neutrinos
   d. atoms

2. Atoms are all made of smaller particles. These particles are the

   a. photon, nucleus, electron
   b. photon, neutron, proton
   c. proton, neutron, electron
   d. proton, nucleus, electron

3. The atomic particle which jumps from atom to atom and makes up electricity is the

   a. proton
   b. electron
   c. neutron
   d. nucleus

4. Polarity is best described as the

   a. direction of electrical current in a conductor
   b. ability of electrons to jump atoms
   c. electrical temperature of an atom
   d. ability of a conductor to carry electricity

5. Electrons have a __________ charge.

   a. negative
   b. positive
   c. neutral
   d. varying

6. Direct current is the flow of electrons in

   a. a single direction
   b. alternate directions
   c. atoms
   d. opposite directions

7. A circuit is defined as

   a. any conductor
   b. a closed path in which an electrical current can flow
   c. the quickest path for electrons to reach ground
   d. a source of current, a load, and a conductor

8. In most common DC circuits electrons flow from a battery through a load to ________.

   a. a fuse
   b. a bonding system
   c. circuit ground
   d. a switch

9. The polarity of ground in most common DC circuits is

   a. varying
   b. neutral
   c. positive
   d. negative

10. Voltage is best described as

   a. a flow of electrons
   b. a resistance to the flow of electrons
   c. the ability of electricity to do work
   d. electrical force or pressure

11. Current is best described as

   a. a flow of electrons
   b. a resistance to the flow of electrons
   c. the ability of electricity to do work
   d. electrical force or pressure

12. Current is measured in

   a. volts
   b. amperes
   c. ohms
   d. watts

13. Electrical pressure is measured in

   a. volts
   b. amperes
   c. ohms

d. watts

14. Resistance to the flow of electricity is measured in

    a. volts
    b. amperes
    c. ohms
    d. watts

15. The most common source of electricity in direct current circuits is

    a. an alternator
    b. a generator
    c. a battery
    d. magnetic induction

16. The process of making electricity by moving magnets near a coiled conductor is called

    a. magnetic alternation
    b. electro-chemical induction
    c. magnetic induction
    d. magneto generation

17. The process by which batteries generate electricity is called

    a. magnetic alternation
    b. electro-chemical induction
    c. magnetic induction
    d. magneto generation

18. The wet cell batteries used to power outboard engine starting systems are made from

    a. lead and acid
    b. copper and acid
    c. lead sulfate and water
    d. copper sulfate and acid

19. Wet cell lead/acid batteries used to power 12 volt systems have ______ cells.

    a. 12
    b. 6
    c. 4
    d. 3

20. Each cell in a 12 volt lead/acid battery produces about ______ volts.

a. 1
b. 2
c. 3
d. 4

21. A ________ is an example of a semiconductor.

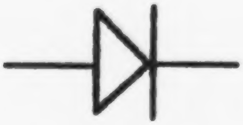
a. fuse
b. capacitor
c. light bulb
d. transistor

22. The best description of the function of a capacitor is

a. storage
b. resistance
c. varying resistance
d. amplifying

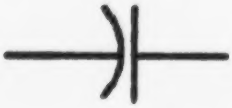
23. The following is the symbol for

a. resistor
b. capacitor
c. diode
d. SCR



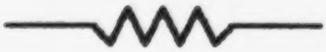
24.

a. resistor
b. capacitor
c. diode
d. SCR



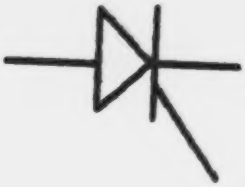
25.

a. resistor
b. capacitor
c. diode



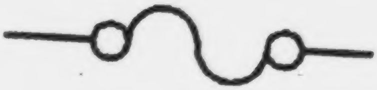
d. SCR

26.



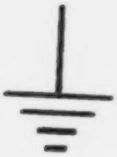
a. resistor
b. capacitor
c. diode
d. SCR

27. The following is the symbol for



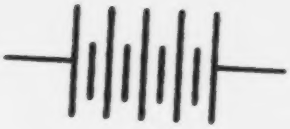
a. fuse
b. ground
c. battery
d. coil

28.



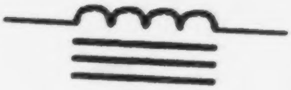
a. fuse
b. ground
c. battery
d. coil

29.



a. fuse
b. ground
c. battery
d. coil

30.



a. fuse
b. ground
c. battery

d. coil

31. Use the remaining space to sketch a circuit diagram for a bilge blower with an indicator light that comes on when the blower switch is turned on.

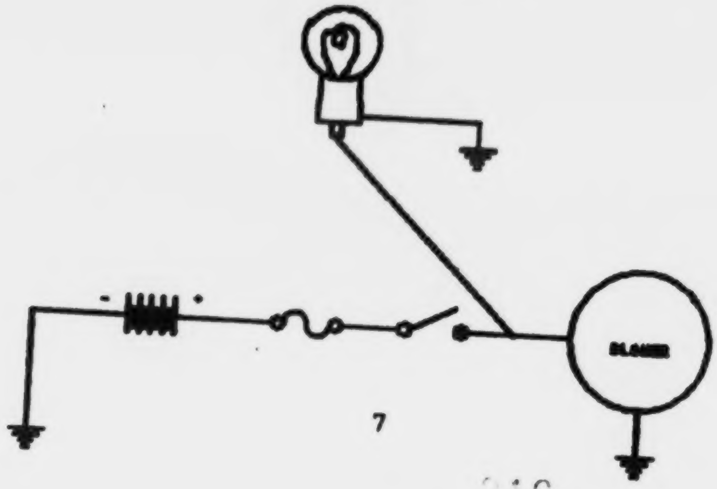
MODULE 09.01

Multiple Choice Test

ANSWER KEY

1. D
2. C
3. B
4. A
5. A
6. A
7. B
8. C
9. D
10. D
11. A
12. B
13. A
14. C
15. C
16. C
17. B
18. A
19. B
20. B
21. D
22. A
23. C
24. B
25. A
26. D
27. A
28. B
29. C
30. D

31.



NAME______________________________ **STUDENT NO.**______________________________

09.01

PERFORMANCE CHECKLIST

MODULE : **UNDERSTANDING ELECTRICITY**

COMPETENCY:
1. Explain the basic principles of electricity
2. Identify electrical devices.
3. Read and interpret wiring diagrams
4. Use a VOM/Multimeter to measure voltage, current, and resistance.

1. ☐ Take test.
2. ☐ Score
3. ☐ Set up VOM/Multimeter for voltage measurements
4. ☐ Made voltage measurements on training aid
5. ☐ Set up VOM/Multimeter for current measurements
6. ☐ Made current measurements on training aid
7. ☐ Set up VOM/Multimeter to measure resistance
8. ☐ Made resistance measurements on training aid
9. ☐
10. ☐
11. ☐
12. ☐
13. ☐

COMPETENCY ACHIEVED? ☐ **YES** ☐ **NO**

EXPLANATION:

UNIT 10 - PAINTING

MODULE 10.01

PAINTING OUTBOARD MOTOR COMPONENTS **INSTRUCTOR GUIDE**

COMPETENCY:
Repair damaged paint on outboard motor components.

INSTRUCTIONAL OBJECTIVES:
The student will be able to:
1. Degrease and clean engine components.
2. Prepare surfaces by sanding and feathering.
3. Use masking techniques to protect components from overspray.
4. Select spray paint primers and spray paint according to application.
5. Apply primer and spray paint to outboard engine components.
6. Select solvents for cleanup use.

LEARNING ACTIVITIES:
1. Participate in class lectures and discussions. (Objectives 1 - 6)
2. Practice making repairs to painted surfaces as you encounter damaged paint on your projects in the shop.

EVALUATION/CHECK-OUT:
You will be given opportunities to repair damaged paint. The instructor will evaluate your ability to prepare the surfaces to be painted, select primer and paint, and make the necessary repairs. Your performance will be recorded on the Painting Outboard Motor Components performance checklist.

RESOURCES:

LEARNING MATERIALS:
(none used)

EQUIPMENT:
1. Painting Supplies.
    - Sandpaper - 90/100 grit
    - Sandpaper - Wet/Dry, finish grit
    - Masking tape
    - Masking paper
    - Engine Degreaser
    - Paint solvent
    - Cans of spray paint primer
    - Cans of spray paint
    - Particle masks
2. Properly ventilated area for small scale spraying.

AUDIO VISUAL MATERIALS:
(none used)

NAME________________________ STUDENT NO.________________________

10.01 **PERFORMANCE CHECKLIST**

MODULE : PAINTING OUTBOARD ENGINE COMPONENTS

COMPETENCY: Repair damaged paint on outboard motor components

1. ☐ Degreased and cleaned surface to be painted
2. ☐ Sanded surfaces
3. ☐ Feathered scratches and chips
4. ☐ Cleaned surfaces after sanding
5. ☐ Masked areas not requiring paint
6. ☐ Selected safe painting area
7. ☐ Used personal particle mask
8. ☐ Applied primer properly
9. ☐ Applied finish coat of paint correctly
10. ☐ Selected solvent for cleanup
11. ☐ Followed clean up procedure
12. ☐
13. ☐
14. ☐
15. ☐

COMPETENCY ACHIEVED? ☐ **YES** ☐ **NO**

EXPLANATION:

UNIT 11 - WELDING

MODULE 11.01

USING OXY/ACETYLENE AND ARC WELDERS INSTRUCTOR GUIDE

COMPETENCY:

1. Use the oxy/acetylene welding kit to cut and make simple butt and lap welds in light gauge steel.
2. Use an arc welder to make simple butt and lap welds in light gauge steel.

INSTRUCTIONAL OBJECTIVES:

The student will be able to:

1. Distinguish aluminum, steel, and stainless steel.
2. Recognize and name the parts of the oxy/acetylene welding kit.
3. Follow safety procedures when working with the oxy/acetylene welding kit.
4. Set up the oxy/acetylene welding kit for cutting.
5. Use the oxy/acetylene welding kit to cut light gauge steel.
6. Set up the oxy/acetylene welding kit for welding.
7. Make butt and lap welds in light gauge steel with the oxy/acetylene welding kit.
8. Shut down the oxy/acetylene welding kit.
9. Recognize and name the parts of the arc welder.
10. Follow safety procedures when working with the arc welding kit.
11. Set up the arc welding kit for welding.
12. Make butt and lap welds in light gauge steel with the arc welding kit.
13. Shut down the arc welding kit.

LEARNING ACTIVITIES:

1. Participate in class lectures and discussions.
   (Objectives 1 - 13)
2. Observe the following demonstrations:
   Using the Oxy/Acetylene Welding Kit Safely
   Setting Up and Shutting The Oxy/Acetylene Welder
   Cutting With The Oxy/Acetylene Welder
   Making Butt and Lap Welds With The Oxy/Acetylene Welder
   Using The Arc Welder Safely
   Setting up and Shutting Down The Arc Welder
   Making Butt and Lap Welds With The Arc Welder
   (Objectives 1 - 13)
3. Review the information sheet "Setting Up The Oxy/Acetylene Torch For Heating" from module 03.02, Freeing Seized Hardware.
   (Objectives 3 - 6)
4. Practice setting up and shutting down the oxy/acetylene and arc welders in the shop.
   (Objectives 9 - 13)
5. Set up the oxy/acetylene welder and make cuts and practice welds on

scrap pieces of steel.
(Objectives 2 - 8)

6. Set up the arc welder and make practice welds on scrap pieces of steel.
(Objectives 9 - 13)

EVALUATION/CHECK-OUT:

You will be evaluated on you ability to set up, shut down, cut, and make practice welds with the oxy/acetylene and arc welding kits. If possible and/or practical you will be given the opportunity to make repair welds on boats, trailers, or engines in the shop. Your ability to make these repair welds will be evaluated on the Using The Oxy/Acetylene and Arc Welders performance checklist.

RESOURCES:

LEARNING MATERIALS:

1. Information Sheet
"Setting UP The Oxy/Acetylene Torch For Heating"
(Master copy included with Module 03.02, "Freeing Seized Hardware".)

EQUIPMENT:

1. Oxy/Acetylene welding kit.
2. Arc welding kit.
3. Arc welding rods.
4. Examples/samples of aluminum, steel, stainless steel.
5. Pieces of light gauge steel for making practice welds.

(For a complete list of tool specifications see the tool list in the front part of this document.)

AUDIO VISUAL MATERIALS:

(none used)

NAME__________________________ **STUDENT NO.**__________________________

11.01 **PERFORMANCE CHECKLIST** 1 of 2

MODULE : **USING OXY/ACETYLENE AND ARC WELDERS**

COMPETENCY: Cut and weld light gauge steel with the oxy/acetylene welding kit.

1. ☐ Recognized and named the parts of the torch kit
2. ☐ Distinguished aluminum, steel, stainless steel
3. ☐ Set up torch for cutting
4. ☐ Made cuts in light gauge steel
5. ☐ Set up torch for welding
6. ☐ Made butt welds
7. ☐ Made lap welds
8. ☐ Shut torch down
9. ☐ Followed all safety procedures
10. ☐
11. ☐
12. ☐
13. ☐
14. ☐
15. ☐

COMPETENCY ACHIEVED? ☐ **YES** ☐ **NO**

EXPLANATION:

NAME__________________________ **STUDENT NO.**__________________________

11.01 **PERFORMANCE CHECKLIST** 2 of 2

MODULE : **USING OXY/ACETYLENE AND ARC WELDERS**

COMPETENCY: Cut and weld light gauge steel with the arc welding kit.

1. ☐ Recognized and named the parts of the arc welding kit
2. ☐ Distinguished aluminum, steel, stainless steel
3. ☐ Set up arc welder for welding
4. ☐ Made butt welds
5. ☐ Made lap welds
6. ☐ Shut arc welder down
7. ☐ Followed all safety procedures
8. ☐
9. ☐
10. ☐
11. ☐
12. ☐
13. ☐
14. ☐
15. ☐

COMPETENCY ACHIEVED? ☐ **YES** ☐ **NO**

EXPLANATION:

UNIT 12 - OUTBOARD IGNITION SYSTEMS

MODULE 12.01

PERFORMING THE BASIC MOTOR INSPECTION **INSTRUCTOR GUIDE**

COMPETENCY:
1. Perform a outboard motor basic inspection.

INSTRUCTIONAL OBJECTIVES:

The student will be able to:
1. State the reasons why a basic motor inspection should be performed before working on an outboard motor.
2. List the five procedures which make up a basic motor inspection.
3. State the procedure for performing a visual inspection of an outboard motor.
4. Visually inspect an outboard motor.
5. State the purpose of a compression check.
6. State the procedure for testing compression on an electric and manual start outboard motors.
7. Test the compression on manual and electric start outboard motors.
8. State the purpose of a rod endplay check.
9. State the procedure for performing a rod endplay check.
10. Perform a rod endplay check.
11. State the purpose of a spark check.
12. State the procedure to use for checking spark on an outboard motor.
13. Select test equipment and perform a spark check.
14. State without error the purpose of a gearcase check.
15. State the procedure to use for performing a gearcase check.
16. Select test equipment and perform a gearcase check.

LEARNING ACTIVITIES:
1. Read the Information Sheet titled "The Basic Outboard Motor Inspection".
   (Objectives 1 - 16)
2. Participate in class lectures and discussions.
   (Objectives 1 - 16)
3. Select the required tools and perform the basic motor inspection on a manual start motor and an electric start motor. Record your results on the Motor Inspection Worksheet.
   (Objectives 4, 7, 10, 13, 16)

EVALUATION/CHECK-OUT:
1. Inspect a motor and submit your Motor Inspection Worksheet.
2. Take the Motor Inspection multiple choice test and score 70% or better.

RESOURCES:

LEARNING MATERIALS:

MODULE 12.01

1. Information Sheet "The Basic Motor Inspection", (master copy included in this guide.
2. Copies of the Motor Inspection Worksheet, (master copy included in this guide).
3. Copies of the Basic Motor Inspection multiple choice test, (master copy included in this guide).

EQUIPMENT:

1. Manual start outboard motors on boat or appropriate stand.
2. Electric start outboard motors on boat or appropriate stand.
3. Compression gauge, remote start switch, air gap spark checker, service manuals, oil catch pan, and hand tools as required.

AUDIO VISUAL MATERIALS:

(none used)

MODULE 12.01

IGNITION SYSTEMS INFORMATION SHEET

The Basic Outboard Motor Inspection

The Basic Outboard Motor Inspection is a set of procedures used to check the basic function of an outboard engine. It is designed to provide information on the general health of the motor's major components which are the powerhead, ignition system, and gearcase.

The information gained by performing the basic motor inspection is useful in three ways. First, it keeps the shop and the customer advised of the general condition of the motor to more effectively apply preventative maintenance procedures. Second, it provides a beginning point for the technician when the engine cannot be started and test run or when little diagnostic information can be provided by the customer. Third, it allows a more accurate estimate of repairs to made thus avoiding "surprise" invoice amounts when the customer comes in to pick up his boat. Additionally the Basic Motor Inspection may help the technician avoid making costly repairs to an engine that should be replaced or has other serious problems that should be brought yo the customers attention before proceeding.

The Basic Motor Inspection should be performed every time an outboard motor comes into the shop. It makes sense to do it even if the boat is in the shop for some purpose other than engine repairs. Finding unexpected trouble with the engine can save the customer a bad day on the water and provide the shop with extra business.

There are four procedures which make up the Basic Motor Inspection. They are the Visual Check, the Spark Check, the Powerhead Check, and the Gearcase Check. The Visual Inspection is designed to detect visible problems such as broken or cracked wires or fuel lines, cracked castings, evidence of overheating problems, worn or stuck control or steering cables, damaged propellers, malfunctioning trim/tilt, worn or broken motor mounts, and damaged boat transoms. The Spark Check tests the basic operation of the ignition system. It determines if there is total or partial loss of spark and identifies the cylinders which may have problems. The Powerhead Check consists of a compression test and a rod endplay check. It provides information on the condition of the cylinders, pistons, piston rings, and rod bearings. The Gearcase Check consists of a visual inspection to look for cracks or other physical damage and a gear lube check. The gear lube is examined for the presence of water or metal filings. Water in the gear lube can indicate the need to replace gearcase seals. Metal filings in the gear lube indicate that the gearcase should be disassembled and its internal components checked for physical damage and wear.

MODULE 12.01

THE BASIC MOTOR INSPECTION

1. Visual Check
2. Spark Check
3. Powerhead Check
4. Gearcase Check

Visual Check

1. Try the steering.
    - Does it work?
    - Does the cable bind?
    - What is the condition of the steering cable?
2. Try the trim/tilt.
    - Does it work?
    - Is the battery OK?
    - What is the fluid level?
3. Remove the motor cover.
4. Try the control box.
    - Does it bind?
    - Does the throttle advance?
    - Does the gearcase shift?
    - Does the choke or enricher operate?
    - What is the condition of control cables?
5. Examine the fuel tank.
    - Are there leaks or cracks?
    - Is the tank vent operational?
    - Can you detect water in the fuel?
    - Does the fuel smell sour?
    - Does there appear to be oil in the fuel?
6. Examine any oil tanks/reservoirs.
    - Are there leaks or cracks?
    - Is the oil level adequate?
    - How is the oil screen/filter?
    - Is the tank contaminated?
    - Is the system primed?
7. Examine the tank side fuel/oil lines.
    - Are there cracks or kinks or leaks?
    - Does the fuel primer ball work?
    - Do the fittings appear undamaged and safe?
    - Are there improper filters in the line?
8. Examine the engine side fuel/oil lines.
    - Are there cracks or kinks or leaks?
    - Are they terminated properly?
    - What is the condition of the fuel filter or screen?
9. Examine the electrical system.
    - Are connections OK?

Are wires cracked or broken?
Any evidence of melted components or burnt wires?
Any missing components?
What is the condition of fuses and circuit breakers?

10. Examine the powerhead.
    - Any evidence of overheating?
    - Are there any detectable cracks in the crankcase or block?
    - Any evidence of exhaust leaks?
    - Any evidence of water jacket leaks?
    - Are water hoses cracked, damaged, or leaking?
    - Are all the head bolts in place?
    - Are carburetors installed on manifold properly?
    - Does the flywheel look alright?
    - Do the throttle, timing, and shift linkages appear OK?
11. Examine motor mounts and brackets.
    - Any excessive wobble?
    - What is the condition of the tilt tube?
    - How do the through-transom mounting bolts look?
12. Examine the propeller.
    - Are the blades cracked, bent, chipped or worn?
    - Is there any obvious hub slip?
13. Examine boat transom.
    - Any physical damage?
    - Does it appear safe?
    - Does it move when motor tilted or turned?

Spark Check

1. Remove the spark plug wires from the spark plugs.
2. Try turning the engine over with the keyswitch/pull starter.
    - Does it turn over?
    - Is the battery OK?
    - What is the condition of the starter?
    - For electric starters, are starter cables OK?
    - Is the starter solenoid OK?
3. Install your remote start switch and an air gap spark checker. Disconnect kill circuit. Crank engine and observe air gap spark checker.
    - Does engine have spark?
    - Which cylinders have no spark?
    - Does spark leak from ignition coils or plug wires?

Powerhead Check

1. Remove spark plugs.
    - What is the condition of the plugs?
    - Are the plug threads in the cylinder head OK?
2. Test the compression in each cylinder. Make sure to disable the

ignition system for safety.
  Do all cylinders have adequate compression?
  Is there a 15 psi difference between any two cylinders?
3. Perform a check for excessive rod endplay in all cylinders.
  (Make sure to disconnect battery on electric start models.)

Gearcase Check

1. Inspect gearhousing for evidence of cracks or other physical damage.
   - If there are zincs present what is there condition?
   - Is skeg bent?
   - How is the trim tab?
2. Remove a small sample of gear lube.
   - What is the condition of the gear lube?
   - Is there any water in the gearcase?
   - Are there any metal filings in the gear lube?
   - How many filings are stuck to the drain screw magnet?
   - What is the condition of the drain and fill screw gaskets?

MOTOR INSPECTION WORKSHEET

MODEL # ____________________ **YEAR** ____________________

VISUAL CHECK

SPARK CHECK

POWERHEAD CHECK

COMPRESSION

ROD ENDPLAY

GEARCASE CHECK

MODEL # ____________________ **YEAR** ____________________

VISUAL CHECK

SPARK CHECK

POWERHEAD CHECK

COMPRESSION

ROD ENDPLAY

GEARCASE CHECK

MODULE 12.01

MARINE MECHANICS
PERFORMING THE BASIC MOTOR INSPECTION

NAME________________________________ STUDENT #____________________

1. The basic motor inspection should be performed

   a) annually.
   b) semiannually.
   c) monthly.
   d) every time the boat comes into the shop.

2. Which one of the following tools is not required to do a basic motor inspection?

   a) remote start switch
   b) air gap spark checker
   c) screwdriver
   d) gearcase pressure checker

3. A powerhead reference picture is a useful aid during the ______ check.

   a) visual
   b) spark
   c) powerhead
   d) gearcase

4. During the spark check the air gap spark checker should be set

   a) to the recommended test gap.
   b) somewhere on the powerhead.
   c) to the widest gap to force problems to show up.
   d) on the HIGH setting.

5. The compression check provides information on

   a) exhaust manifold pressure.
   b) the general condition of pistons, rings, and cylinders.
   c) cylinder scavenging.
   d) intake and exhaust ports.

6. The rod endplay check provides information on the general condition of the

   a) connecting rod.

b) rod bearings.
c) crankshaft main bearings.
d) sealing rings.

7. The rod endplay check is performed using a

a) blunt screwdriver.
b) stethoscope, (for listening).
c) dial indicator and base.
d) piston stop

8. The remote start switch used to crank an electric start engine during the spark and compression checks is connected to the

a) battery and starter motor.
b) starter solenoid and ground.
c) across the starter solenoid terminals.
d) to the battery and hot solenoid terminal.

9. Before performing a rod endplay check you must first

a) do a gearcase check.
b) disconnect the battery.
c) torque the head bolts.
d) check the flywheel.

10. Gear lube which has water in it looks

a) like butterscotch pudding.
b) blue in color.
c) the same but is thicker.
d) dark black.

11. Before performing a compression test you must

a) inform the customer.
b) disable the ignition system.
c) say "Clear" loudly.
d) remove the remote start switch.

12. A difference of _____ psi compression between 2 cylinders is a sign of cylinder trouble.

a) 5
b) 10
c) 15
d) 20

13. In order to properly inspect the gear lube in an outboard motor gearcase you must

a) drain the entire gearcase.
b) draw a small sample from the vent screw hole.
c) test it with the gear lube sample kit.
d) draw a small sample from the fill screw hole.

14. If an ignition system shows no spark during a spark check you should

a) inform the service manager.
b) check the set up and repeat the test.
c) call the customer to revise his estimate.
d) install another battery.

15. If a customer refuses additional repairs on items you have found as a result of the basic motor inspection you should

a) refuse to work on the motor.
b) make the repairs anyway.
c) make a note on the service order and proceed.
d) discount the original invoice so the customer can have the additional work done.

MODULE 12.01

MARINE MECHANICS
PERFORMING THE BASIC MOTOR INSPECTION

Answer Key

1. D
2. D
3. A
4. A
5. B
6. B
7. A
8. D
9. B
10. A
11. B
12. C
13. D
14. B
15. C

NAME______________________________ **STUDENT NO.**_____________________________

12.01 **PERFORMANCE CHECKLIST**

MODULE : PERFORMING THE BASIC MOTOR INSPECTION

COMPETENCY: PERFORM A MOTOR INSPECTION

1. ☐ Turn in your Motor Inspection Worksheet.
2. ☐ Take Motor Inspection multiple choice test.
3. ☐ Score
4. ☐
5. ☐
6. ☐
7. ☐
8. ☐
9. ☐
10. ☐
11. ☐
12. ☐
13. ☐
14. ☐
15. ☐

COMPETENCY ACHIEVED? ☐ **YES** ☐ **NO**

EXPLANATION:

MODULE 12.02

IDENTIFYING IGNITION SYSTEMS **INSTRUCTOR GUIDE**

COMPETENCY:
Recognize ignition systems and components.

INSTRUCTIONAL OBJECTIVES:

The student will be able to :
1. Label the parts of an ignition coil.
2. State the general method by which a spark is produced.
3. Explain the relationship between crankshaft position and spark timing.
4. Label BTDC, TDC, and ATDC on a flywheel timing grid.
5. Discuss the relationship of spark timing and throttle position.
6. Explain the mechanisms by which ignition timing is advanced and retarded.
7. Name the two critical points in the timing range of an outboard motor ignition.
8. Label the parts of a battery ignition, magneto ignition, CD ignition , and a magneto CD ignition.
9. Draw a general circuit diagrams of straight battery, magneto, CD, and magneto CD ignition systems.
10. State the purpose of the condenser in straight battery and magneto ignition systems.
11. State the purpose of breaker points in straight battery. and magneto ignition systems.
12. Discuss the events in the production of an ignition spark for the various types of ignition systems.
13. Recognize the various types of ignition systems on motors.

LEARNING ACTIVITIES:
1. Participate in class lectures and discussions.
   (Objectives 1 - 13)
2. Select a model/year engine for each one of the various types of ignition systems then look up and list the ignition system parts for each.
   (Objective 8)
3. Sketch a basic circuit diagram for each of the various ignitions systems. Include and label the major ignition components, stop circuit, and battery if necessary.
   (Objectives 8,9)
4. Read pages 1 through 10 in the Yamaha ignition systems workbook and the booklet "OMC Magneto/CD Ignition System Theory.
   (Objectives 5 - 7, 10 - 12)
5. Complete the Terms Worksheet by filling in definitions for the ignition system terms and phrases listed on the worksheet.

(Objectives 3 - 6)
6. View the videotape "Introduction To CD-II Ignition" from OMC.
   (Objectives 1 - 13)
7. Locate engines in the shop which have each of the various types of ignition systems. Write down the type of ignition system, model and serial numbers for each.
   (Objective 13)

EVALUATION/CHECK-OUT:

1. Submit your circuit diagrams.
2. Submit your parts lists.
3. Submit your list of engine model and serial numbers.
4. Submit your terms worksheet.
5. Take the Identifying Ignition Systems multiple choice test and score 70% or better.

RESOURCES:

LEARNING MATERIALS:

1. Information Sheet - "OMC Ignition System Model History", (master copy included in this guide)
2. Information Sheet - "Magneto Type CD Ignitions", (master copy included in this guide).
3. Copies of the Yamaha marine seminar workbook "Ignition and Charging Systems". Yamaha Motor Corporation, U.S.A.
4. Copies of "OMC Magneto/CD Ignition System Theory".
   Part 406412.
   Outboard Marine Corporation of Canada Ltd.
   Peterborough, Canada
5. Copies of the Terms Worksheet, (master included in this guide)
6. Copies of the Ignition Systems multiple choice test, (master included in this guide)

EQUIPMENT:

1. Outboard motors including different models/years that represent each of the various types of ignition systems.
2. Parts catalogs ,printed or microfiche, and microfiche viewer.

AUDIO VISUAL MATERIALS:

"Introduction to CDII Ignitions", Videotape.
OMC VT799 OB
OMC Service Dept., Desk C-13
3145 Central Ave.
Waukegan, IL 60085
(312)629-7192

MODULE 12.02

IGNITION SYSTEMS TERMS WORKSHEET

Define the following terms or phrases.

1. Before Top Dead Center, BTDC -

2. After Top Dead Center, ATDC -

3. Top Dead Center, TDC -

4. Spark Timing -

5. Wide Open Throttle,(WOT), timing -

6. Pickup timing -

7. Timing curve -

8. Timing grid -

9. Timing pointer -

10. Magnetic induction -

11. Charge coil -

12. Pulse/Sense/Trigger coil -

13. Capacitor/Condenser -

14. Thyristor/SCR -

15. Rise time -

MODULE 12.02

IGNITION SYSTEMS INFORMATION SHEET

OMC IGNITION SYSTEM MODEL HISTORY (1967 - 1986)

HORSEPOWER	IGNITION TYPE AND MODEL YEAR
1.5	MAGNETO 1968-70
2	MAGNETO 1968-
3	MAGNETO 1967,1968
4	MAGNETO 1967-76, 1981- ; CDII 1977-80
4 DEL	CDII 1985-
4.5	CDII 1980-83
5	MAGNETO 1967,1968
6	MAGNETO 1967-76 ; CDII 1977-79, 1984
7.5	CDII 1980-83
8	CDII 1984-
9.5	MAGNETO 1967-73
9.9	LOW TENSION 1974-76 ; CDII 1977-
15	LOW TENSION 1974-76 ; CDII 1977-
18	MAGNETO 1967-72 ; LOW TENSION 1973,1974
20	MAGNETO 1967-72 ; LOW TENSION 1973 ; CDII 1984-
25	MAGNETO 1969-72 ; LOW TENSION 1973-76 ; CDII 1977-
25 COM	CDII 1978-
30	CDII 1984-
33	MAGNETO 1968-70
35	LOW TENSION 1976 ; CDII 1977-
40	MAGNETO 1967-74 ; LOW TENSION 1974-76 ; CDII 1984-
40 COM	LOW TENSION 1981-83 ; CDII 1984,85
45 COM	CDII 1986-
50	MAG CD 1971-75 ; CDII 1979-
50 COM	CDII 1978,79
55	BAT CD 1968,69 ; MAG CD 1976,77 ; CDII 1978,79
55 COM	CDII 1980-
65	BAT CD 1968 ; MAG CD 1972,73
65 COM	CD 3/6 1984-
70	MAG CD 1974-78 ; CD 3/6 1979-
75	MAG CD 1975-78 ; CD 3/6 1979-
80	BATTERY 1967
85	BAT CD 1968-72 ; MAG CD 1973-77 ; CD IV 1978-80
90	CD IV 1981-
100	BAT CD 1967-72 ; CD IV 1978 1/2-80
100 COM	CD IV 1984-
110	CD IV 1986-
115	BAT CD 1969,70 ; MAG CD 1973-77 ; CD IV 1978-
120	CD 4/8 1985-
125	BAT CD 1971,72
135	MAG CD 1973-76
140	MAG CD 1977 ; CD IV 1978-84 ; CD 4/8 1985-

MODULE 12.02

150 .... MAG CD 1978 1/2 ; CD 3/6 1979-
150 GT/XP ..... CD 3/6 1983-
155 COM .... CD 3/6 1984-
175 .... MAG CD 1977,78 ; CD 3/6 1979-
185 .... CD 3/6 1984,85
200 GT/XP ..... CD 6 1986-
200 .... MAG CD 1976-78 ; CD 3/6 1979-83
225 .... CD 6 1986-
2.61 .... CD 3/6 1983-85
275 .... CD 4/8 1985-
3.61 GT/XP .... CD 4/8 1985-

MODULE 12.02

IGNITION SYSTEMS INFORMATION SHEET

MAGNETO TYPE CD IGNITIONS

When it comes to ignition systems speed is measured in millionths of a second. Each one millionth of a second is called a microsecond. The time in microseconds it takes an ignition system to build spark plug voltage from zero to the point of firing is called rise time.

The faster a system's rise time, the less opportunity there is for voltage to leak off. A Capacitor Discharge ignition has a rise time of approximately two microseconds. An ordinary system's rise time would be about one hundred microseconds.

Benefits of the CD ignition system include smoother idling and low speed operation and longer spark plug life. There are no moving parts to wear out, no breaker points, nothing to adjust.

The CD ignition works by flywheel magnets whirling by copper wound coils to produce the initial energy. The copper wound coils are called charge coils and the energy produced is about three hundred volts. This charging current moves to a pulse pack to be stored in a capacitor and is discharged into an ignition coil as needed. The ultra high voltage obtained from the ignition coil is transmitted to the spark plug through short leads to minimize any voltage loss thus maximizing power. Because of the short spark plug leads the ignition coils must be placed near the spark plug.

Distribution of the ignition pulses is handled by an electronic triggering device. There are magnets in the flywheel which induce a small current in sensor coils. This current is used to trigger electronic switches called Silicone Controlled rectifiers or SCR's. The SCR's release the energy stored in the capacitor into the ignition coil where it is amplified to produce a spark. In this way mechanical parts like breaker points, cams, belts, pulleys, and their adjustments are eliminated.

The magneto type CD ignition requires no battery to operate because all the energy necessary to operate the system is produced by the flywheel magnets and charge coil.

The magneto type CD ignition is extremely durable in normal use but can be easily damaged by improper operation, testing, or servicing procedures. The following procedures should be observed:

1. Make sure that all wiring connections are clean and tight.
2. Make certain that wires do not bind or rub on moving parts or touch metal edges where they may chafe through their insulation.

3. Do not make or break any electrical connections while the engine is running.
4. Do not use an electric tachometer other than the one recommended by the manufacturer.
5. Do not hold the spark plug wires while checking for spark.

MARINE MECHANICS
IDENTIFYING IGNITION SYSTEMS

NAME:______________________________ STUDENT NO.__________________

1. The performance of the magneto ignition system ______________ as engine RPM increases.

   a) levels off
   b) decreases
   c) breaks up
   d) improves

2. The primary purpose of the condenser in a straight battery or magneto ignition system is to

   a) remove moisture from under the flywheel.
   b) prevent arcing in the breaker points.
   c) cause a rapid build up of the electrical field. around the primary windings.
   d) filter the current going to the ignition coil.

3. The part of the ignition coil which has the most turns of wire is the

   a) primary windings.
   b) secondary windings.
   c) core laminate.
   d) none, the coil is oil filled.

4. In a magneto ignition system one end of the primary winding is connected to ground and the other end is connected to

   a) the breakers points and condenser
   b) the spark plug wire
   c) the mag chip
   d) the secondary windings

5. The secondary windings of an ignition coil are connected to ground on one end and ________________ on the other.

   a) the breakers points and condenser
   b) the spark plug wire
   c) the mag chip
   d) the secondary windings

6. In a magneto ignition system voltage is induced in the ________

when the ___________ passes by it.

a) spark plug, electricity
b) capacitor, magnet
c) secondary windings, magnet
d) primary windings, magnet

7. In a magneto ignition when the flywheel magnet begins to pass the coil the field is built up in a certain direction by the leading pole. As the trailing opposite pole of the magnet comes closer to the coil the field already built up in the coil will want to resist the change in field direction that the opposite pole will cause. When this resistance is at it greatest

a) the condenser fires.
b) the motor shuts off.
c) the breaker points open.
d) the breaker points are useless.

8. The length of time that the breaker points stay closed is referred to as

a) dwell
b) pickup timing
c) rise time
d) a microsecond

9. In a straight battery or magneto ignition system the condenser

a) improves pickup timing.
b) helps cause a rapid collapse of the field built up around the primary windings.
c) can usually be disconnected
d) charges the kill circuit

10. The points are opened and closed in a controlled manner by

a) timing pointer
b) timer base
c) breaker cam
d) flywheel

11. A spark jumps the spark plug gap when the breaker points

a) close.
b) are .020" apart.
c) fire into the condenser.
d) open.

12. In a magneto ignition system the breaker cam is located on the

a) timer base.

b) distributor.
c) crankshaft.
d) mag plate.

13. The ________________ screw is used to adjust the breaker point gap.

a) allen.
b) eccentric.
c) posidriv.
d) timing.

14. In a magneto ignition system the spark timing is varied by turning the

a) magplate.
b) breaker cam.
c) timing pointer.
d) timing screw.

15. The size of the breaker point gap affects the

a) dwell.
b) condenser load.
c) room under the flywheel.
d) coil alignment.

16. The "CD" in the term CD ignition refers to

a) coil discharge.
b) capacitor discharge.
c) constantly discharging.
d) constant dwell.

17. The mag CD ignition system was designed to

a) eliminate the need for batteries.
b) improve idle and low speed engine operation.
c) replace mechanical parts that wear out.
d) b and c.

18. The point gap in a magneto CD ignition system should be set to

a) minimum allowable gap.
b) .020"
c) mag CD ignitions have no breaker points.
d) mag CD ignitions have breaker points but they are not adjustable.

19. In a mag CD ignition system the ignition coils are located

a) under the flywheel.

b) in the power pack.
c) near the timing linkage.
d) as close to the spark plug as possible.

20. Mag CD ignition systems have short spark plug wires because

a) they are very expensive.
b) they eliminate heat problems in the ignition coil.
c) there is less chance of spark voltage leak off.
d) longer ones are not needed.

21. In a mag CD ignition coil the primary field is energized by

a) the flywheel magnets.
b) the battery.
c) the release of a charge stored in the capacitor.
d) breaker points.

22. The capacitor gets its charge in a mag CD ignition from

a) the battery.
b) the charging system.
c) the breaker points.
d) the charge coil.

23. The alternating current produced by the charge coil must be converted to direct current to charge the capacitor. This is done in the

a) capacitor.
b) power pack.
c) charging system.
d) charge coil.

24. The ______________ is/are responsible for producing a small voltage to trigger the capacitor to release its stored charge.

a) trigger/sensor coils
b) breaker points
c) ignition coils
d) timer base

25. The electronic device used to fire the capacitor's charge into the ignition coil primary is the

a) tachometer
b) silicone controlled rectifier, (SCR)
c) diode
d) bridge rectifier

26. There are ____________ SCR's in a CD power pack.

a) 1
b) 2
c) usually 1 per ignition coil
d) usually 2 per ignition coil

27. Spark timing in a mag CD ignition system is accomplished by

a) turning the timing screw.
b) using a timing light.
c) the power pack.
d) the position of the trigger/sensor coils and their magnets in the flywheel.

28. The spark timing in a mag CD ignition system is varied by

a) turning the timing screw.
b) adjusting the charge coil.
c) shimming the flywheel.
d) rotating the timer base

MARINE MECHANICS
IDENTIFYING IGNITION SYSTEMS

MULTIPLE CHOICE TEST ANSWER KEY

1. D
2. B
3. B
4. A
5. B
6. D
7. C
8. A
9. B
10. C
11. D
12. C
13. B
14. A
15. A
16. B
17. D
18. C
19. D
20. C
21. C
22. D
23. B
24. A
25. B
26. C
27. D
28. D

NAME____________________________ **STUDENT NO.**_________________________

12.02

PERFORMANCE CHECKLIST

MODULE : IGNITION SYSTEMS

COMPETENCY: IDENTIFYING IGNITION SYSTEMS

1. ☐ Turn in your ignition circuit diagrams.
2. ☐ Turn in your ignition system parts lists.
3. ☐ Turn in your list of engine models and serial numbers.
4. ☐ Turn in your terms worksheet.
5. ☐ Take ignition system multiple choice test.
6. ☐ Score
7. ☐
8. ☐
9. ☐
10. ☐
11. ☐
12. ☐
13. ☐
14. ☐
15. ☐

COMPETENCY ACHIEVED? ☐ **YES** ☐ **NO**

EXPLANATION:

MODULE 12.03

REPAIRING AND MAINTAINING IGNITION SYSTEMS INSTRUCTOR GUIDE

COMPETENCY:
Repair and adjust to specification outboard motor ignition systems.

INSTRUCTIONAL OBJECTIVES:

The student will be able to:

1. Prevent accidents while working on ignition systems.
2. State the purpose of a timing pointer on an outboard engine.
3. State the number of the engine cylinder which is usually used for setting engine timing.
4. Set up a timing light and read timing on an engine which is operating at idle and WOT speed.
5. Explain the mechanism by which a timing light operates.
6. Set adjustable timing pointers.
7. Synchronize ignition timer base and carburetor linkages.
8. Set maximum spark advance.
9. List the possible defective ignition system components when an unacceptable spark check is observed.
10. Recognize and maintain ignition system special tools.
11. Remove and replace flywheels.
12. Troubleshoot and repair outboard motor emergency stop switches.
13. Troubleshoot and repair key switches in magneto and magneto CD systems.
14. Troubleshoot and repair magneto ignition systems.
15. Troubleshoot and repair magneto CD ignition systems.
16. Perform a tune up on a magneto ignition system.
17. Perform a tune up on a magneto CD ignition system.

LEARNING ACTIVITIES:
References to specific brand names of ignition systems have not been made in this module. The instructor should provide product knowledge as dictated by his/her experience and familiarity.

1. Participate in class lectures and discussions.
   (Objectives 1 - 17)
2. Read and study the following Information Sheets:
   "Ignition System Safety Procedures"
   "Troubleshooting Magneto Ignition"
   "Troubleshooting Magneto CD Ignitions"
   (Objectives 1 - 17)
3. Read the ignition system sections of the service manuals for the engines which will be used for shop demonstrations.
   (Objectives 1 -17)
4. View the videotape "Principles of Spark-Throttle Adjustment"
   (Objectives 6 - 8)

5. Observe the following demonstrations:
    - Flywheel removal
    - Mag-plate removal and disassembly
    - Magneto ignition component tests
    - Mag-plate assembly and adjustment
    - Magneto Ignition System Synch and Link
    - Magneto CD ignition component test
    - Magneto CD Synch and Link

   (Objectives 1 - 17)
6. Practice mag plate removal, test, and adjust procedures on a training motor in the shop.
   (Objectives 1 - 14, 16)
7. Practice magneto CD test and adjust procedures on a training motor in the shop.
   (Objectives 1 - 13, 15, 17)
8. Troubleshoot, repair, and maintain magneto and magneto CD ignition systems on bugged training motors and/or live work provided by instructor.
   (Objectives 1 - 17)

EVALUATION/CHECK-OUT:

1. Troubleshoot and repair the defective magneto ignition system assigned to you by the instructor. Record your results on the service order. The instructor will record your performance on the Performance Checklist.
2. Troubleshoot and repair the defective magneto CD ignition system assigned to you by the instructor. Record your results on the service order. The Instructor will record your performance on the Performance Checklist.

RESOURCES:

LEARNING MATERIALS:

1. Information Sheet - "Ignition System Safety Procedures", (master copy included with this guide).
2. Information Sheet - "Troubleshooting Magneto Ignitions", (master copy included in this guide).
3. Information Sheet - "Troubleshooting Magneto CD Ignitions", (master copy included in this guide)

EQUIPMENT:

1. Engines for demonstrating ignition system troubleshooting, repair, and synch & link techniques.
2. Student tool kits.
   (Refer to the Tools section of this document for specifications.)
3. Ignition system special tools
    - peak reading voltmeter
    - volt/ohmmeter
    - timing light

remote start button
portable tachometer
air gap spark checker
neon spark tester

(Refer to the Tools section of this document for specifications.)

4. Live work or bugged engines for students to practice troubleshooting and repair techniques. If live work will be used try to plan ahead and arrange for engines to be brought in.
5. Engine test tank.

AUDIO VISUAL MATERIALS:

1. Videotape

"Principles of Spark-Throttle Adjustment"
P/N VT7070B
OMC Training Department
3145 Central Avenue
Desk C-613
Waukegan, IL 60085
(312) 689-5531

MODULE 12.03

IGNITIONS SYSTEMS INFORMATION SHEET

IGNITION SYSTEM SAFETY

The ignition coils used on outboard motors generally output in the range of 15,000 to 30,000 volts. This high level of output when directed into a person's hand can be quite painful but seldom damaging. The danger in becoming inured around live ignition systems lies in what happens when a shock is received while holding tools or equipment. The tools can be thrown or dropped as a result of the rapid withdrawal which takes place when your hand is stung by an ignition jolt. The injuries which can take place because of flying or dropped tools are obvious and the damage caused to dropped test equipment can directly affect your income. The misdirected ignition pulse can also damage CD ignition components causing further undue expense. To avoid accidents and prevent damage to equipment and ignition system components, follow these precautions:

1. **NEVER** place tools or parts on top of the flywheel. If forgotten and the engine is cranked the flying pieces can cause injuries.

2. Before cranking an engine that you have been working on check to see that you have not placed anything on the flywheel and that you have not placed anything on or near the cranking components which could become caught or fouled.

3. When working with people around the motor say the word "CLEAR" loudly and wait for everyone to respond with the word "CLEAR" before cranking the motor. When working with a partner at the control box make sure the two of you are communicating properly by using the same "CLEAR" procedure. If you are the person at the control box DO NOT TURN THE KEY OR CRANK THE MOTOR until everyone near the motor responds with the word "CLEAR".

4. Do not leave plug wires attached to the spark plugs when cranking a motor to test ignition components. A motor can start and run on fewer than all of its cylinders. Attach the plug leads to a properly grounded spark checker.

5. Before cranking a live ignition with the spark plug wires off the spark plugs check the service manual. Some ignition systems may be damaged by cranking with the coil output open.

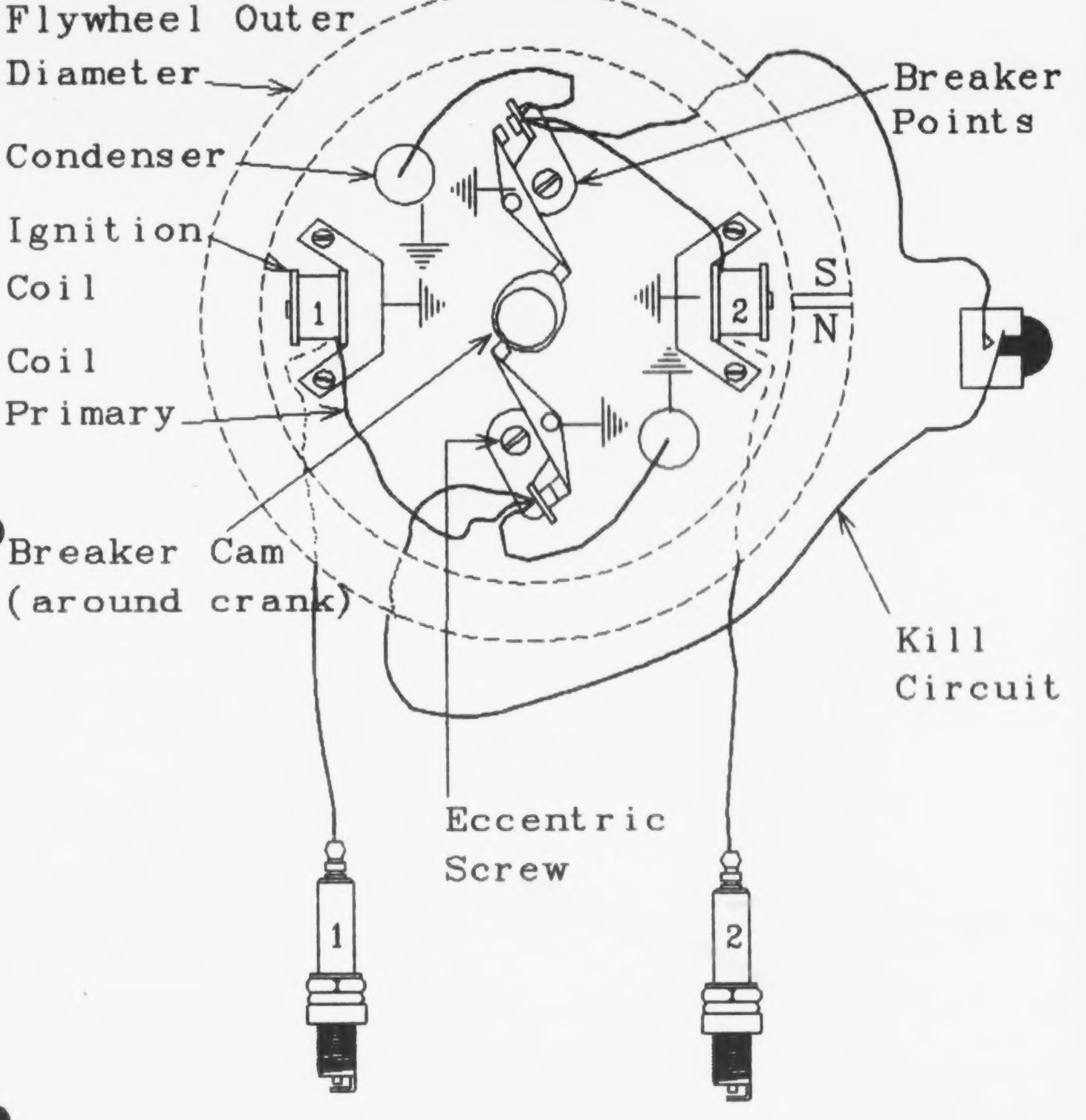
6. **ALWAYS** disconnect the battery before attempting to remove or disassemble any engine component.

7. If you need to pull a plug wire off while test running an engine use a spark plug boot puller. Check the insulation on the tool before using it.

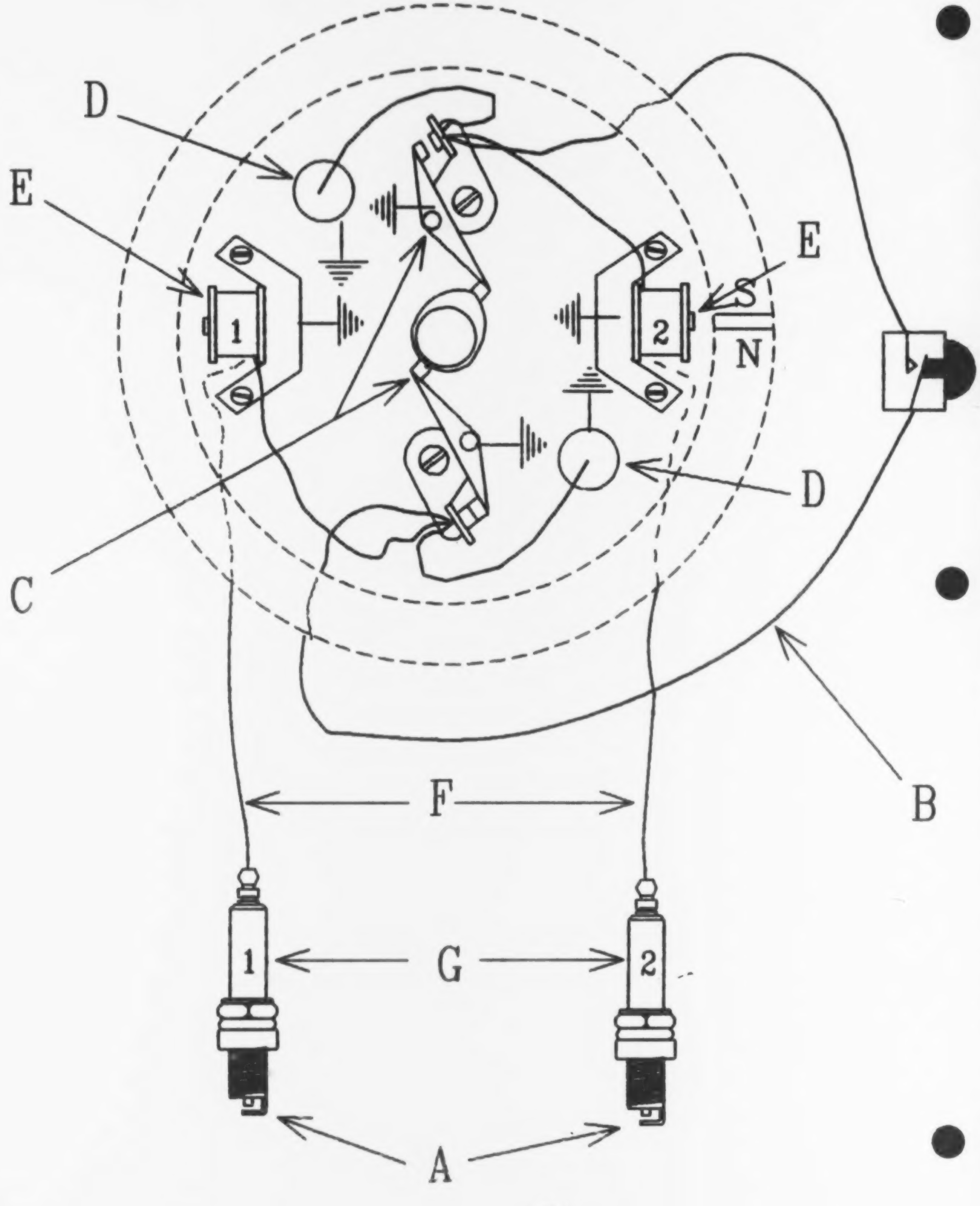
before using it.

8. Never connect or disconnect ignition system electrical circuits while test running a motor.

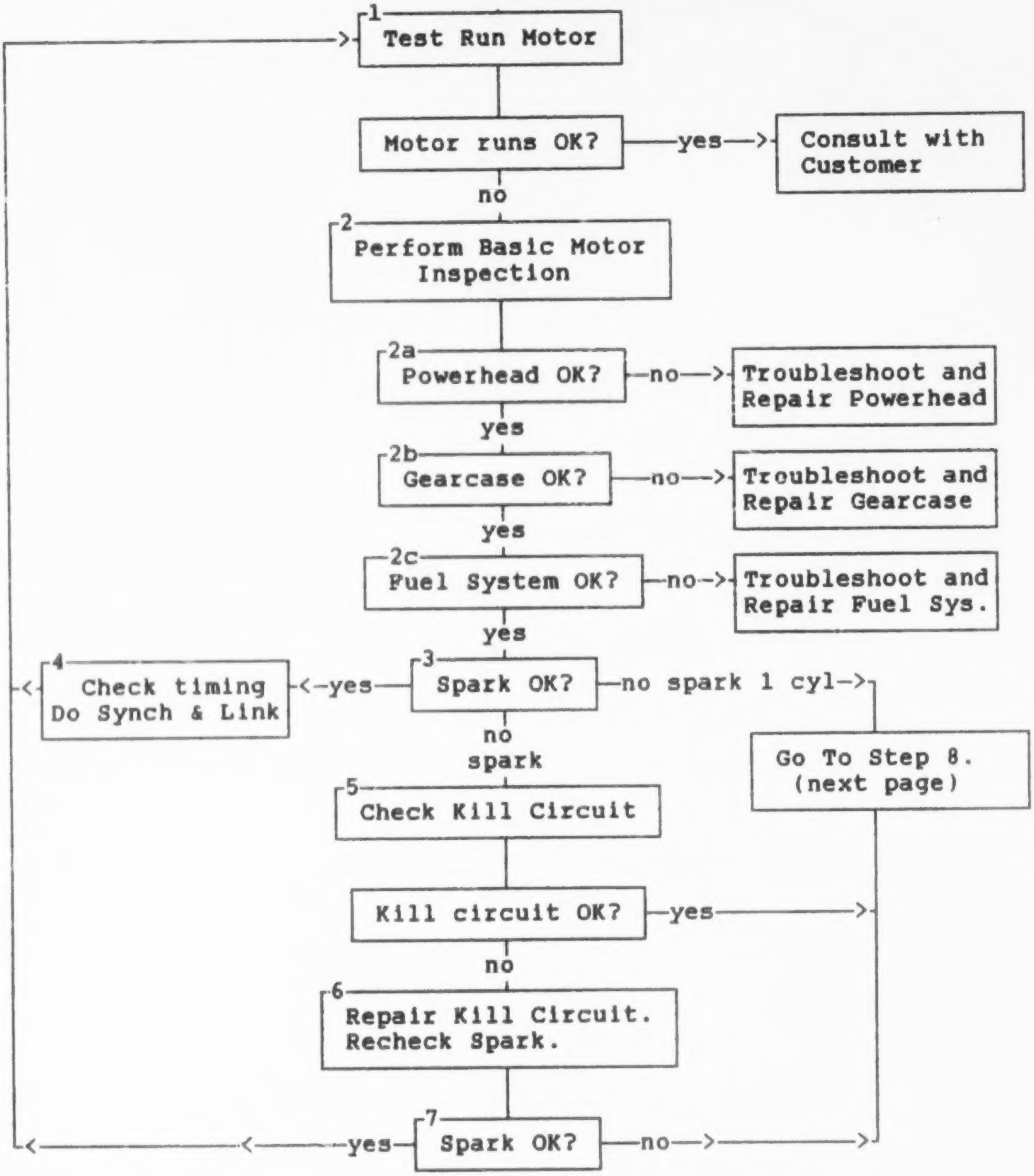
Simplified 2 Cylinder Magneto

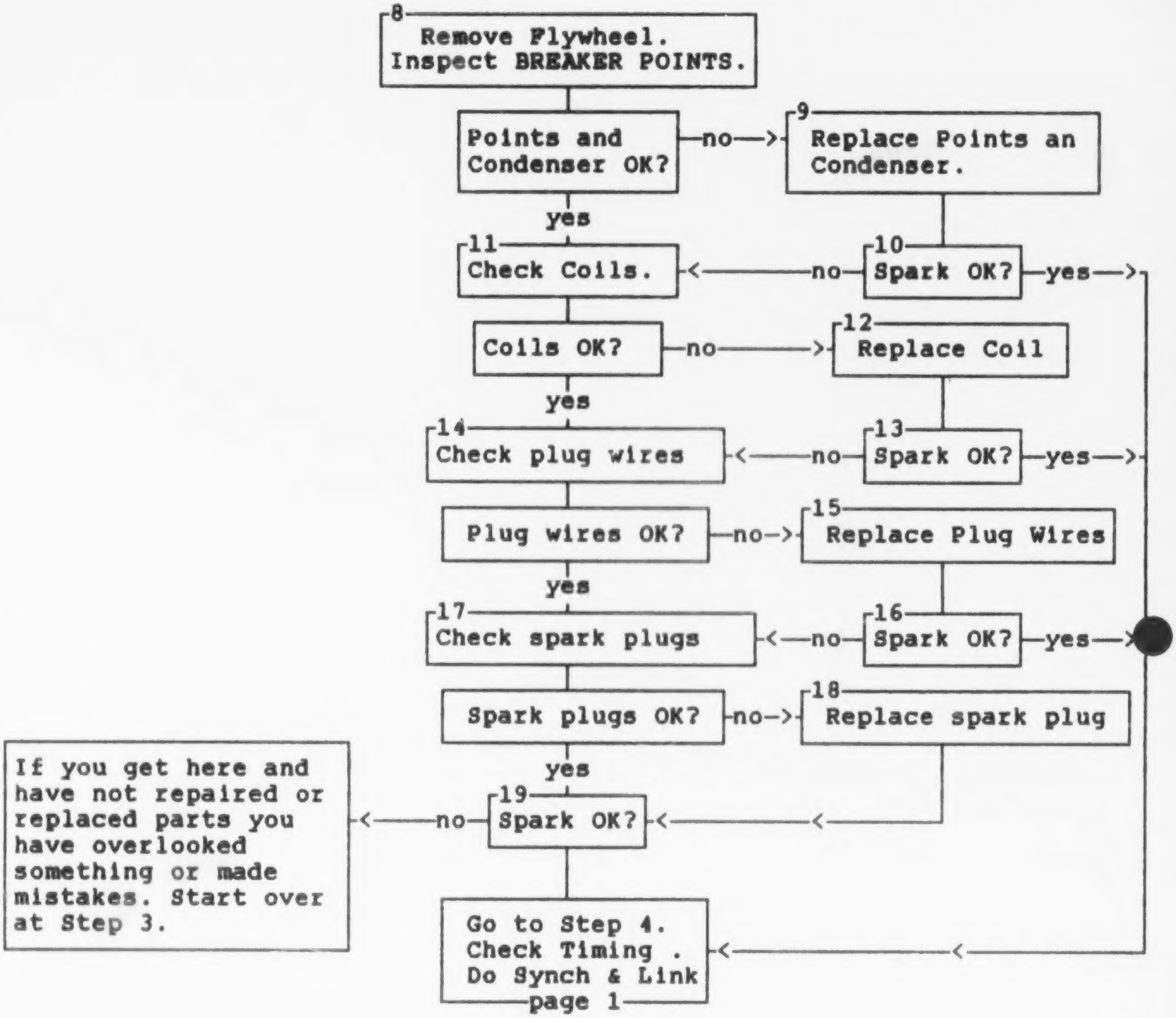

Flywheel Outer Diameter
Breaker Points
Condenser
Ignition Coil
Coil Primary
1
2
S
N
Breaker Cam (around crank)
Kill Circuit
Eccentric Screw
1
2

Magneto Test Points

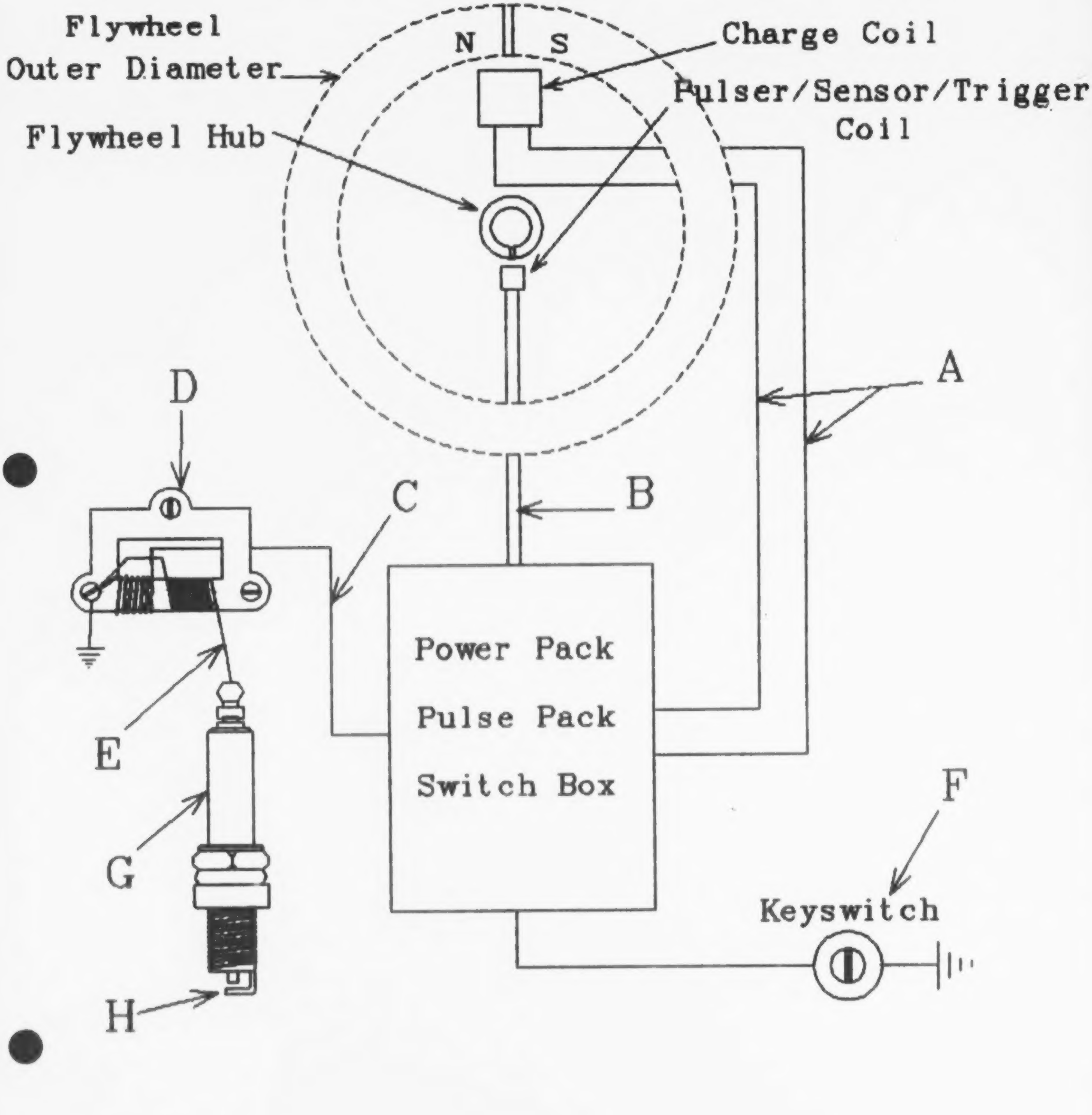

D
E
E
S
N
1
2
D
C
B
F
G
1
2
A

TROUBLESHOOTING MAGNETO SYSTEMS

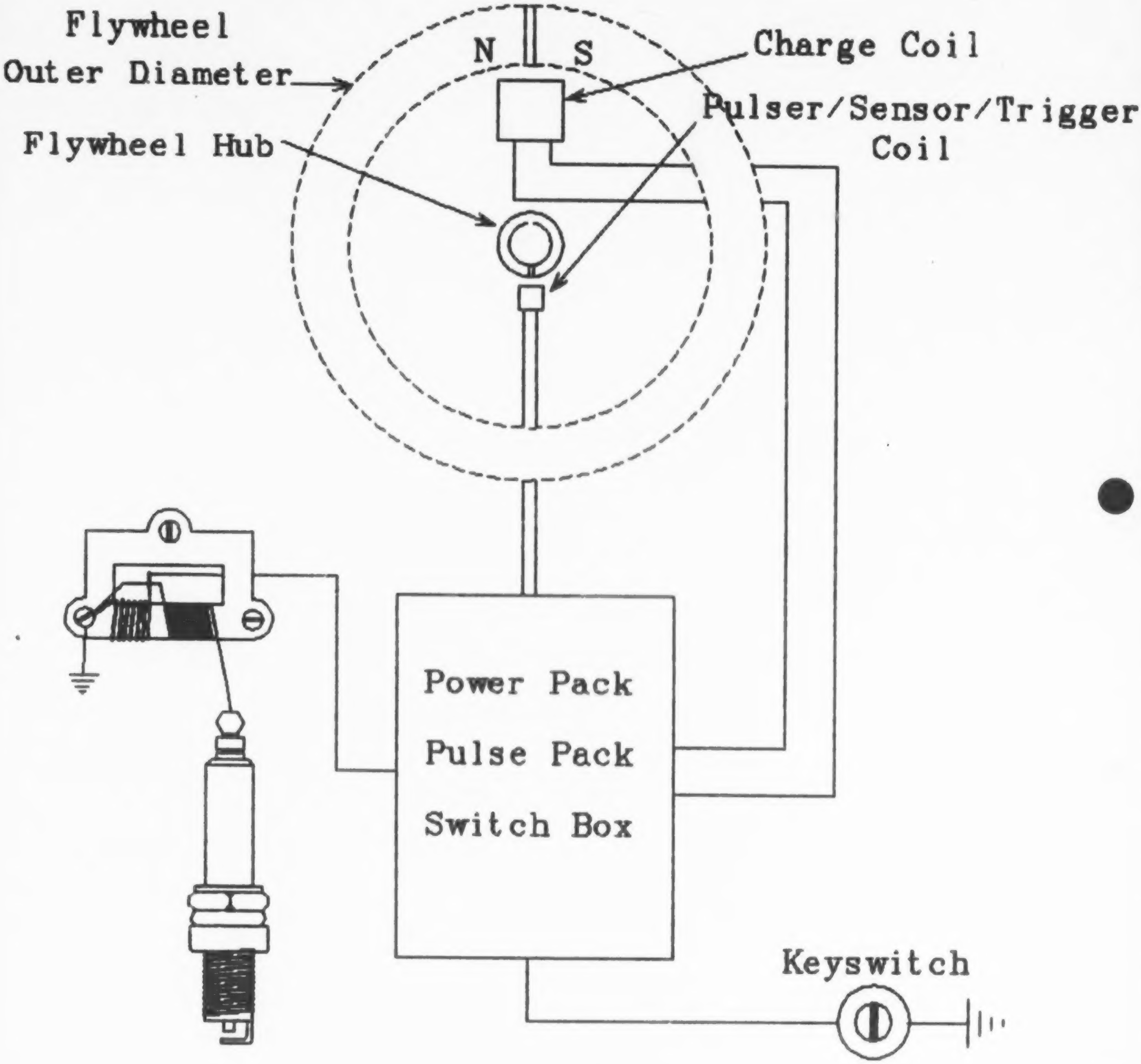

1
Test Run Motor
Motor runs OK?
yes
Consult with Customer
no
2
Perform Basic Motor Inspection
2a
Powerhead OK?
no
Troubleshoot and Repair Powerhead
yes
2b
Gearcase OK?
no
Troubleshoot and Repair Gearcase
yes
2c
Fuel System OK?
no
Troubleshoot and Repair Fuel Sys.
yes
4
Check timing Do Synch & Link
yes
3
Spark OK?
no spark 1 cyl
no spark
Go To Step 8. (next page)
5
Check Kill Circuit
Kill circuit OK?
yes
no
6
Repair Kill Circuit. Recheck Spark.
yes
7
Spark OK?
no


8
Remove Flywheel.
Inspect BREAKER POINTS.
Points and Condenser OK?
no
9
Replace Points an Condenser.
yes
11
Check Coils.
no
10
Spark OK?
yes
Coils OK?
no
12
Replace Coil
yes
14
Check plug wires
no
13
Spark OK?
yes
Plug wires OK?
no
15
Replace Plug Wires
yes
17
Check spark plugs
no
16
Spark OK?
yes
Spark plugs OK?
no
18
Replace spark plug
If you get here and have not repaired or replaced parts you have overlooked something or made mistakes. Start over at Step 3.
yes
no
19
Spark OK?
Go to Step 4. Check Timing . Do Synch & Link
page 1

Magneto CD Test Points

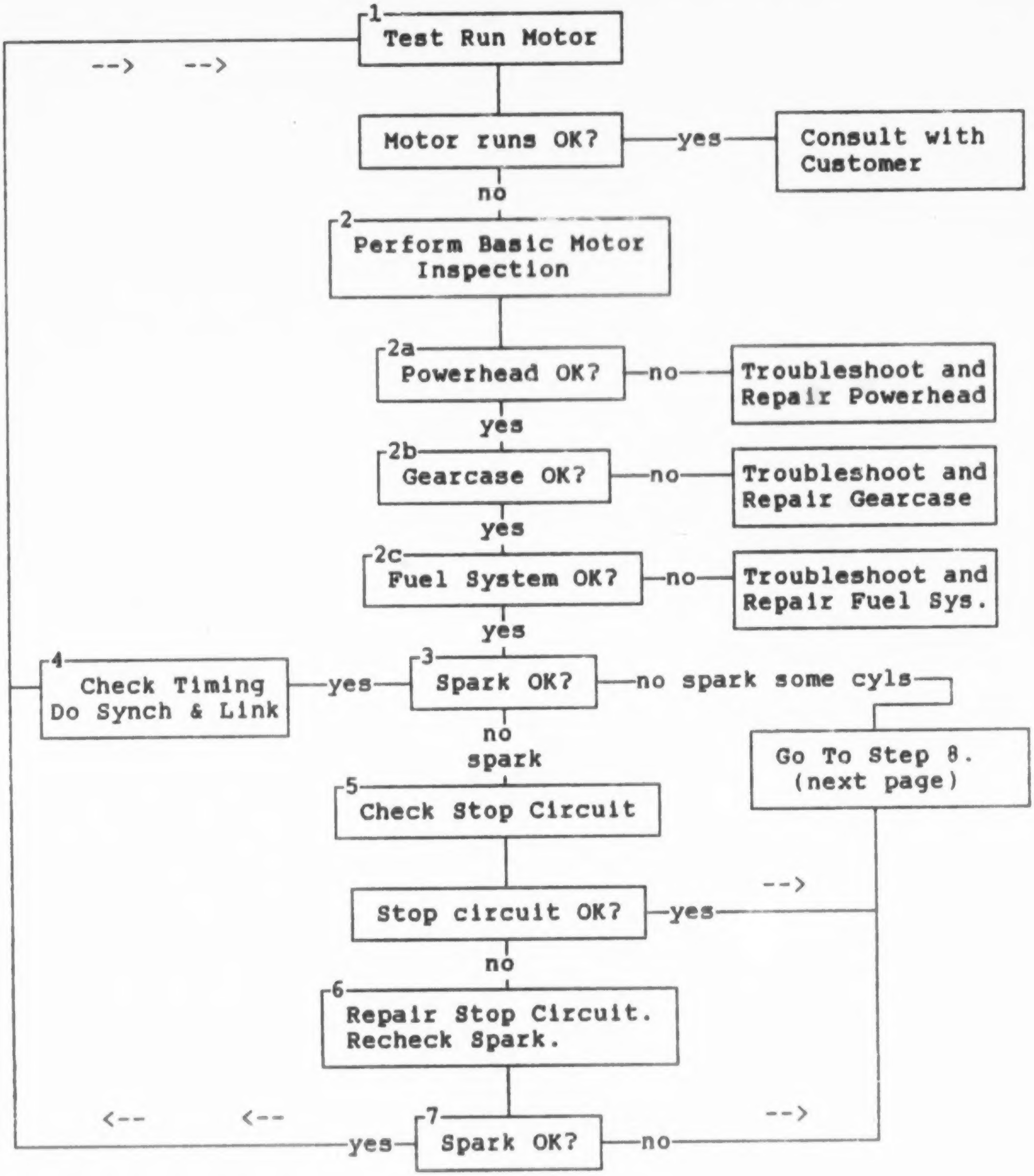

Flywheel
Outer Diameter
N
S
Charge Coil
Pulser/Sensor/Trigger
Coil
Flywheel Hub
A
D
C
B
Power Pack
Pulse Pack
Switch Box
E
G
F
Keyswitch
H

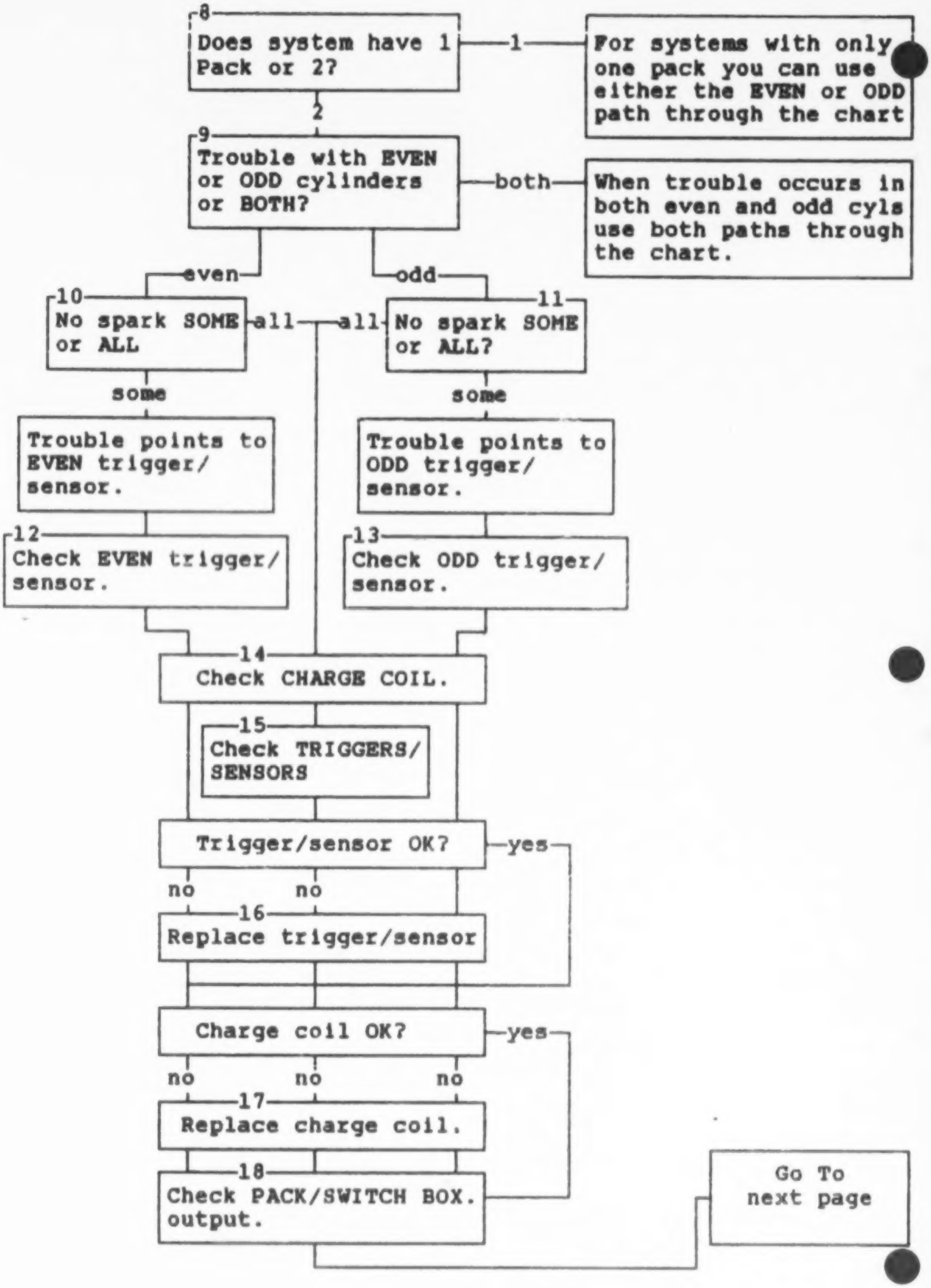
Simplified Magneto CD Ignition

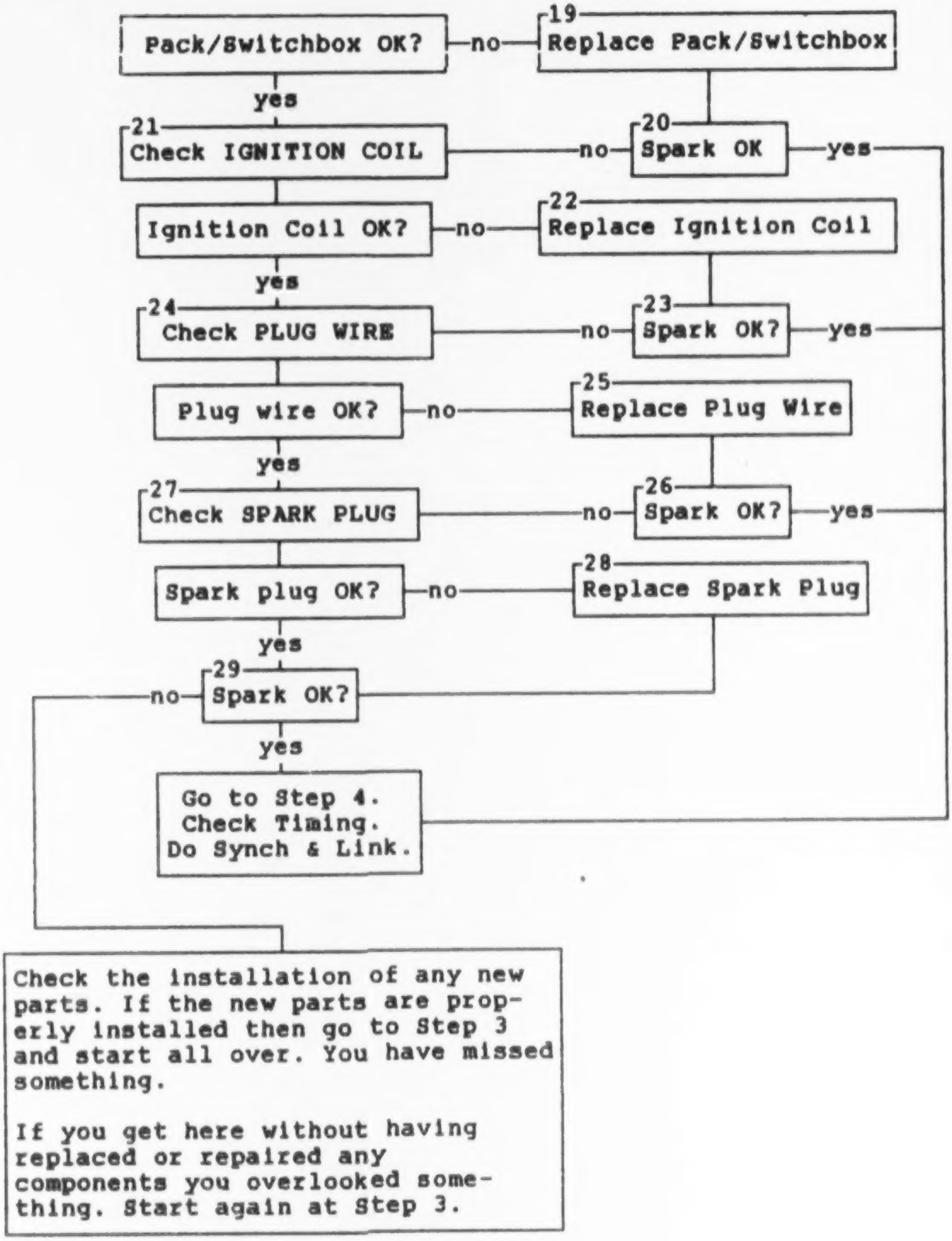

Flywheel
Outer Diameter
N
S
Charge Coil
Pulser/Sensor/Trigger
Coil
Flywheel Hub
Power Pack
Pulse Pack
Switch Box
Keyswitch

IGNITIONS SYSTEMS INFORMATION SHEET

TROUBLESHOOTING MAGNETO CD SYSTEMS


1
Test Run Motor
-->
-->
Motor runs OK?
yes
Consult with Customer
no
2
Perform Basic Motor Inspection
2a
Powerhead OK?
no
Troubleshoot and Repair Powerhead
yes
2b
Gearcase OK?
no
Troubleshoot and Repair Gearcase
yes
2c
Fuel System OK?
no
Troubleshoot and Repair Fuel Sys.
yes
4
Check Timing Do Synch & Link
yes
3
Spark OK?
no spark some cyls
Go To Step 8. (next page)
no spark
5
Check Stop Circuit
Stop circuit OK?
yes
-->
no
6
Repair Stop Circuit. Recheck Spark.
<--
<--
yes
7
Spark OK?
no
-->


8
Does system have 1 Pack or 2?
1
For systems with only one pack you can use either the EVEN or ODD path through the chart
2
9
Trouble with EVEN or ODD cylinders or BOTH?
both
When trouble occurs in both even and odd cyls use both paths through the chart.
even
odd
10
No spark SOME or ALL
all
all
11
No spark SOME or ALL?
some
some
Trouble points to EVEN trigger/ sensor.
Trouble points to ODD trigger/ sensor.
12
Check EVEN trigger/ sensor.
13
Check ODD trigger/ sensor.
14
Check CHARGE COIL.
15
Check TRIGGERS/ SENSORS
Trigger/sensor OK?
yes
no
no
16
Replace trigger/sensor
Charge coil OK?
yes
no
no
no
17
Replace charge coil.
18
Check PACK/SWITCH BOX. output.
Go To next page


Pack/Switchbox OK?
no
19
Replace Pack/Switchbox
yes
21
Check IGNITION COIL
no
20
Spark OK
yes
Ignition Coil OK?
no
22
Replace Ignition Coil
yes
24
Check PLUG WIRE
no
23
Spark OK?
yes
Plug wire OK?
no
25
Replace Plug Wire
yes
27
Check SPARK PLUG
no
26
Spark OK?
yes
Spark plug OK?
no
28
Replace Spark Plug
yes
29
no
Spark OK?
yes

Go to Step 4.
Check Timing.
Do Synch & Link.

Check the installation of any new parts. If the new parts are properly installed then go to Step 3 and start all over. You have missed something.

If you get here without having replaced or repaired any components you overlooked something. Start again at Step 3.

NAME________________________ STUDENT NO.________________________

12.03 **PERFORMANCE CHECKLIST**

MODULE : REPAIR AND MAINTAIN IGNITION SYSTEMS

COMPETENCY: TROUBLESHOOT AND REPAIR A MAGNETO IGNITION

1. ☐ Performed basic motor inspection
2. ☐ Selected appropriate service manual
3. ☐ Checked service bulletins
4. ☐ Selected and used ignition special tools
5. ☐ Identified faulty coils with coil checker
6. ☐ Removed, replaced, and aligned ignition coils
7. ☐ Identified faulty plug wires with ohmmeter
8. ☐ Removed and replaced spark plug wires
9. ☐ Identified faulty condenser using ohmmeter
10. ☐ Identified defective breaker points using ohmmeter
11. ☐ Removed and replaced breaker points and condenser
12. ☐ Set points using feeler gauge
13. ☐ Set points using timing fixture
14. ☐ Synchronized timing advancer with throttle
15. ☐ Test run engine

COMPETENCY ACHIEVED? ☐ YES ☐ NO

EXPLANATION:

NAME______________________ **STUDENT NO.**______________________

12.03 **PERFORMANCE CHECKLIST** 1 of 2

MODULE : REPAIR AND MAINTAIN IGNITION SYSTEMS

COMPETENCY: Troubleshoot and repair a magneto CD ignition

1. ☐ Performed basic motor inspection
2. ☐ Selected service manual
3. ☐ Checked service bulletins
4. ☐ Selected and use ignition special tools
5. ☐ Detected faulty charge coil with ohmmeter
6. ☐ Detected faulty charge coil with peak reading voltmeter
7. ☐ Detected faulty sensor/trigger with ohmmeter
8. ☐ Found faulty sensor/trigger with peak reading voltmeter
9. ☐ Found faulty power pack with peak reading voltmeter
10. ☐ Removed and replaced stator
11. ☐ Removed and replaced trigger/sensor coils
12. ☐ Removed and replaced power pack/switchbox
13. ☐ Detected bad ignition coil using pack output test
14. ☐ Removed and replaced ignition coil
15. ☐ Detected faulty spark plug wire using ohmmeter

COMPETENCY ACHIEVED? ☐ **YES** ☐ **NO**

EXPLANATION:

NAME______________________________ **STUDENT NO.**____________________________

12.03 **PERFORMANCE CHECKLIST** contd. 2 of 2

MODULE : REPAIR AND MAINTAIN IGNITION SYSTEMS

COMPETENCY: Troubleshoot and repair a magneto CD ignition

16. ☐ Removed and replaced spark plug wire
17. ☐ Detected faulty timer base by inspection
18. ☐ Removed and replaced timer base
19. ☐ Synchronized carburetors
20. ☐ Set throttle stop
21. ☐ Synchronized timing advancer and throttle
22. ☐ Set adjustable timing pointer
23. ☐ Set pick up timing
24. ☐ Set idle speed
25. ☐ Set maximum spark advance

☐

☐

☐

☐

☐

COMPETENCY ACHIEVED? ☐ **YES** ☐ **NO**

EXPLANATION:

MODULE 12.04

SELECTING SPARK PLUGS — INSTRUCTOR GUIDE

COMPETENCY:
Select and install spark plugs.

INSTRUCTIONAL OBJECTIVES:

The student will be able to:
1. Identify the parts of a spark plug in a cross-sectional diagram.
2. Recognize gasket seat and taper seat spark plugs.
3. Explain the meaning of spark plug heat range.
4. Describe the types of spark plug electrodes.
5. Use a spark plug application guide to decode spark plug numbers.
6. Use a spark plug application guide to select spark plugs for a particular application.
7. Install spark plugs correctly.

LEARNING ACTIVITIES:
1. Participate in class lectures and discussions.
   (Objectives 1 - 7)
1. Read and study the Information sheets "Spark Plug Selection" and "Spark Plug Removal and Installation".
   (Objectives 1 - 7)
2. Observe a demonstration of spark plug removal and installation techniques.
   (Objective 7)
3. As you remove and install spark plugs while working on projects in the shop practice using the installation techniques described in the information sheet "Spark Plug Removal and Installation".
   (Objective 7)
4. As you encounter spark plugs in the shop record their numbers then look them up in the Sales Symbols chart. This will help to familiarize you with the characteristics of the common types of marine spark plugs.
   (Objective 5)

EVALUATION/CHECK-OUT:
The instructor will observe your ability to select and install spark plugs for projects in the shop and record your performance on the Spark Plugs Performance Checklist.

RESOURCES:

LEARNING MATERIALS:
1. Information Sheet
   "Spark Plug Selection"
   By Matthew Prendergast

from "Engines", Petersen's Yearbook Series, Volume 2, Number 2, 1988
Petersen Publishing Company
8490 Sunset Blvd.
Los Angeles, CA 90069
(213) 854-2222

2. Information Sheet
"Spark Plug Removal and Installation"
Adapted from the 1989 Champion Spark Plug/Wire and Cable Catalog 500/544, p/n 99141, Champion Spark Plug Company, Toledo, OH 43661

EQUIPMENT:

1. An outboard motor with spark plugs removed, spark plug(s), and a spark plug wrench for demonstrating plug removal and installation techniques.

AUDIO VISUAL MATERIALS:

(none used)

NAME_______________________ **STUDENT NO.**_______________________

PERFORMANCE CHECKLIST

MODULE : Selecting Spark Plugs

COMPETENCY: Select and install spark plugs

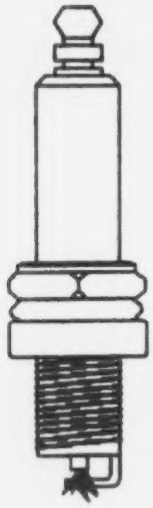
1. ☐ Selected spark plugs by using service manual
2. ☐ Selected spark plugs by using manufacturer's cross ref.
3. ☐ Installed spark plugs using torque wrench
4. ☐ Installed plugs using the finger tight 1/4 turn method
5. ☐ Identified surface gap and J gap spark plugs
6. ☐ Identified gasket seat and taper seat spark plugs
7. ☐
8. ☐
9. ☐
10. ☐
11. ☐
12. ☐
13. ☐
14. ☐
15. ☐

COMPETENCY ACHIEVED? ☐ **YES** ☐ **NO**

EXPLANATION:

Information Sheet

Selecting Spark PLugs



SPARK PLUG SELECTION

Spark Plug selection should be more than just a by-guess or by-golly process.

Editor's Note: *Matthew Prendergast is a Training Instructor at the Allied Aftermarket Division's headquarters in Providence, Rhode Island. He has built and raced cars of his own, and is currently Allied's Autolite spark plug technical liason to many national racing events. In his spare time, Matt is restoring a 1968 Z-28 Camaro. Matt has been with Allied since 1981, when it was known as the Fram Division. If you had the opportunity to visit with the people in the orange "Fram Vans" who travelled the country with service tips and information a few years back, you may have met him.*

By MATTHEW PRENDERGAST

IT'S ONE OF THOSE SAD TRUISMS OF RACING: a $2.00 part can cost you the race—even though you've spent countless hours and thousands of dollars getting "everything right."

Among those vital $2.00 parts are your spark plugs. Consider that detonation resulting from use of a too-hot plug can cause engine damage resulting in a DNF, while cold fouling can keep you from finishing in the money, and it's easy to see that any time spent finding the right plug is time well spent.

There are five basic spark plug types. While not all apply directly to all race cars, knowing something about each should help you better understand the spark plug designs that do apply.

1. Standard Tip Spark Plugs: This type of plug is commonly used in Sprint cars, as well as in other forms of auto racing. These are exactly like spark plugs found in production cars, but racers generally use colder heat ranges. A standard tip plug locates its electrodes right at the plug opening in the cylinder head.

2. Power Tip Spark Plugs: Power tip plugs are also commonly found in production cars, and they are useful in short track racing with its on-the-gas/off-the-gas operation. Again, colder heat ranges are generally used in racing. The electrodes of a power tip plug extend farther into the combustion chamber than a standard tip plug's. The extended tip tends to retain more heat at low speed, helping to fight fouling when idling, following the pace car, or under the yellow flag. However, the electrodes are in the path of the relatively cool incoming fuel/air mixture. This causes an effect, known as "charge cooling," which tends to keep the electrodes from getting too hot at speed.

3. Semi-Power Tip Spark Plugs: This plug fits halfway between the standard tip plug and the power-tip design. Semi-power tip plugs are used when it is desirable to have the electrodes reach further into the combustion chamber than with a standard tip spark plug, but when piston or valve contact would result when using a full-length power tip.

4. Retracted Tip Spark Plugs: As the name implies, the electrodes in this type of spark plug are located inside the plug shell. They run cold and are meant to prevent preignition during extended maximum-throttle running. Retracted tip plugs are generally used in artificially aspirated engines, such as Indy car and IMSA GTP engines, or in applications where there is no room for electrodes in the combustion chamber.

5. Surface Gap Spark Plugs: The spark occurs on the flat bottom portion of a surface-gap plug. These plugs run very cold, and are only usable with magneto or capacitive-discharge ignition systems. Surface-gap plugs are generally found only in racing outboard motorboats or in Formula One engines.

Once a race engine is completed, it only bears a passing resemblance to the passenger-car engine it once was. Because of this, looking up the engine's stock plug and dropping down a few notches colder in heat range is *not* the best way to pick out a plug.

There are five factors that affect your selection of race car spark plugs: physical size and shape requirements; severity of tuning load and combustion chamber turbulence; weight, both in pounds and downforce; fuel type; and length of the track.

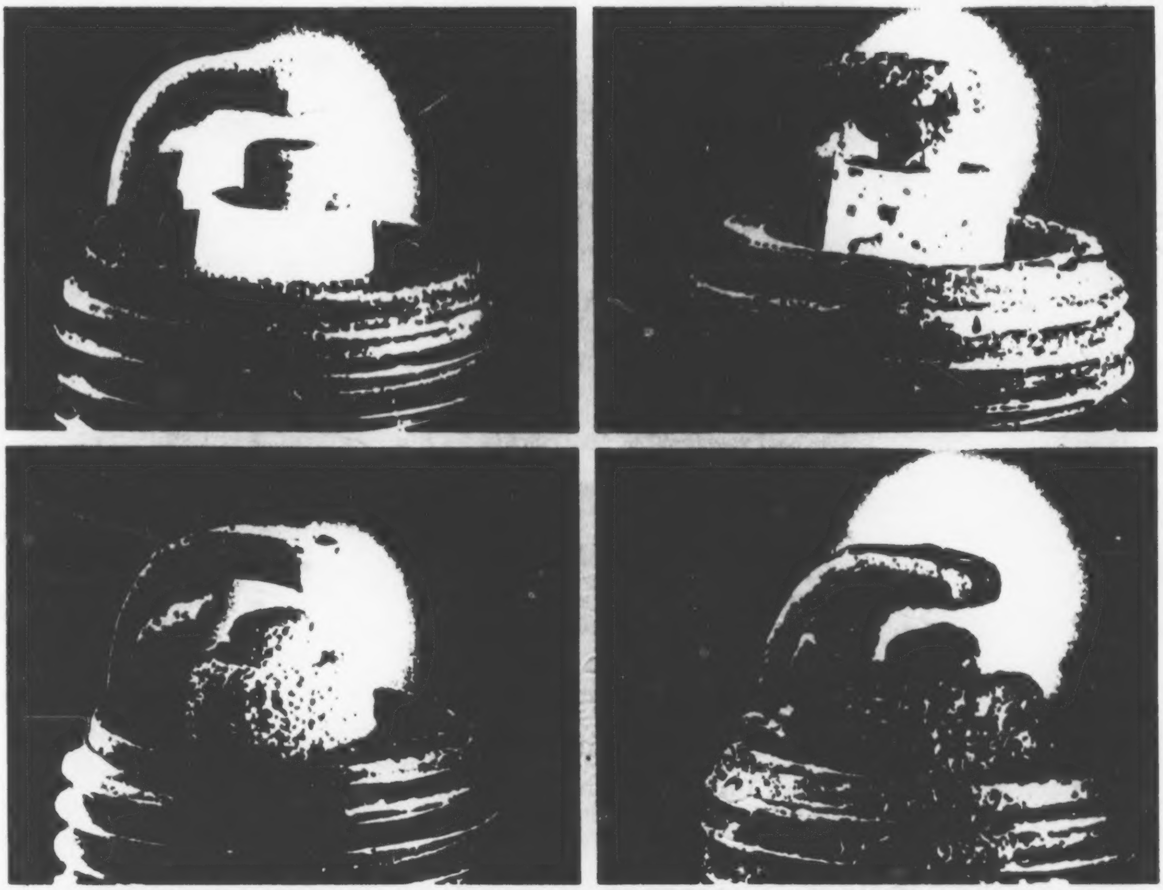
Here are details about each:

1. Spark Plug Size and Configuration: You don't have any say in this matter. Basically you *have* to use spark plugs with the right thread diameter and reach, as well as the right type of seat, to fit the heads you're using.

To be absolutely *sure* the plugs you're using have the proper reach, torque a set of sample plugs in the heads when they're off the engine. If the heads call for gasket seat plugs, be sure the gaskets are in place during this test.

Here is one example of why this is critical: early Chevy V8s used a ⅜-inch-reach, 14mm gasket seat spark plug, but in mid-1971 Chevrolet switched to a tapered-seat plug design. Using tapered seat spark plugs in the older heads will cause an extra .095-inch of thread to stick into the chamber. This puts the electrodes closer to the piston, risking contact. Also, the exposed threads can get hot enough to cause damaging preignition or detonation.

2. Severity of Tuning Load: As a general rule, the more highly tuned an engine, the hotter its combustion chambers get. Wild cam grinds and ultra-high compression ratios tend to put more heat into a spark plug, meaning the plug has to be able to rid itself rapidly of excess heat. Turbulence modifications also generally increase combustion



Here are four spark plugs in various states of health. Clockwise (starting with top left) is a normal plug (slight gray tint and dry); a preignition plug (burnt or melted electrode); a lead-fouled plug (plaster-like coating) and an oil-fouled plug (looks like it's been dipped in greasy mud, then baked). Reading your spark plugs can be the key to diagnosing engine conditions.

chamber temperatures.

3. Weight: All Sprint cars weigh about the same, but don't forget that wing riding up there above your head. If it's set for maximum downforce, that translates into more drag—in effect more *weight*—that the engine has to carry. Similar considerations apply to all types of race cars where engine load is concerned. Loose suspension settings have a similar loading effect. This greater load makes for a hotter-running engine, often requiring a colder spark plug.

4. Fuel Type: All other factors being equal, alcohol runs cooler than gasoline. This means alcohol-fueled engines may require hotter spark plugs. But remember that in switching over to alcohol, all other factors rarely remain equal.

5. Length of Track: An engine tends to run a wide-open throttle for more extended stretches on longer tracks than on shorter tracks. This increases combustion chamber temperature, calling for a colder plug. Also because extended high temperatures tend to erode electrodes, a standard tip plug is often a better choice for long-track running than a power-tip design with its extended electrodes. This is because standard-tip electrodes don't reach as far into the devilishly hot and turbulent center of the combustion chamber. In addition, shorter electrodes make for a shorter heat path, further helping to prevent erosion by letting the plug run cooler.

■ Sorting It All Out

Now that you have all this information, what do you do with it? The first thing is to determine what spark plug configuration correctly fits the hole.

In the case of custom heads, it's up to whoever does the final machine work to determine plug size and seat design. Tight clearance between the plug holes and exhaust manifold flanges, for example, might cause him to machine the heads for tapered seat plugs. (These are often called "peanut plugs" because of their ⅝-inch hex size.)

Once you know what size and shape plugs will fit the heads, turn to the heat range chart in the back of most spark plug catalogs. It lists a variety of plugs of various tip types and heat ranges that have the right dimensions for your heads.

Meanwhile, with production heads, the first step is to look up their original application in a spark plug catalog. As an example, Autolite #16 is listed as fitting the cylinder heads for an '80 Chevy 400-cubic-inch small-block.

Next, find the plug number you got in the applications section in the heat range chart. There, you'll be able to find the part numbers of other plugs, in other heat ranges, that will also fit your heads.

Keep in mind that for most domestic spark plugs the last numerical digit of the part number offers a comparison of heat ranges within a plug family. (An example of plug family would be 14mm-thread, .460-inch-reach, gasket-seal, non-resistor power tip.) As a rule, the lower the last number, the colder the heat range within a family. Once you've found your plug on the chart, you can compare it to others in its family in terms of heat range. Stock plugs will always be too hot for a race engine.

If you want to use the power-tip design, start your testing with the coldest plug in any given family. But what if a power tip spark plug won't clear valves or pistons, or if the car is to be run on a long track where electrode erosion might be a problem with

PHOTOGRAPHY COURTESY OF AUTOLITE

the power-tip design? This is another question the heat range chart can help answer. For automobile spark plugs only, resistor, non-resistor, standard, or power-tip part numbers on the same line are more-or-less comparable in heat range. In other words, should a power tip plug have originally fit your engine, but you need to use a standard-tip model, use the standard plug listed alongside your ideal power tip plug. If there isn't one on the same line, play it safe; look lower in the chart for a colder spark plug.

■ Tips About Resistance

What about using resistor plugs? In coil-type ignition systems, they behave the same as non-resistor plugs, except they don't interfere with electronic equipment. But certain magnetos can be damaged if the secondary-circuit resistance is too high. Check the recommendations of your magneto manufacturer.

This brings up another variable: gap. How big should it be? Whatever your ignition manufacturer suggests! For instance, because secondary-circuit resistance increases with the size of the gap, magneto makers generally call for a gap of .028-inch or less. But the makers of some capacitive discharge systems call for a gap of .050-inch or larger. This means that in the case of two engines that are identical except that one has a magneto and the other a CD system, the same spark plug could conceivably be correct for each, but with a larger gap in the CD engine.

■ The Ideal Spark Plug

To find the right spark plug for your engine, start with the coldest model in the family you've chosen, and work your way hotter until you find the right heat range. This way, if you start off with too-cold plugs, they'll simply foul. But if you start with too-hot plugs, they could cause detonation and ruin the engine. Better to sacrifice $16.00 worth of spark plugs!

Armed with the information above, you're ready to put your engine on the dyno and try plugs. Now, it's a matter of testing to see what heat range you need, based on your fuel type and how "wild" the engine is tuned. As for weight and drag factors, you'll have to dial them into the dyno.

Before you torque-in the first test set of plugs, clean the black oxide coating, if the plugs are so coated, off a section of the threads on each of them. Use a wire wheel and clean the threads behind the ground electrode. (This way the electrode keeps the wire wheel from contacting the plug's ceramic insulator. The insulator is porous; such contact could provide a fouling path and lead to misfiring.) Removing the coating will make it possible for you to accurately read the heat marks that will show up on the plug threads.

The first set of plugs you try might be cold enough to foul, but maybe not. The right plugs are the ones that are hot enough to not foul and that produce peak power. But how do you know if they're *too* hot?

Take them out and look at the working ends. There should be some heat discoloration in the metal, and when the plugs are right, the discoloration will have a certain

Heat Range:
The relative measure of a spark plug's ability to remove heat from its electrodes. This is determined by the length of the heat path from the center electrode, through the ceramic insulator, to the metal shell of the plug. Plugs with longer heat paths run hotter than those with shorter heat paths.

Understanding Heat Range

Why is Heat Range Critical?

It is the measure of how fast the spark plug tip dissipates combustion heat. It must do this in a controlled manner that will:

1. Stay cool enough to avoid preignition and/or electrode destruction.
2. Run hot enough to burn off combustion deposits that would otherwise collect at the firing tip.
3. Adapt to specific engine characteristics and widely varying driving/load conditions.

NOW
ON SALE

WHATEVER YOU DRIVE
OR RIDE, ON OR OFF
THE ROAD, PETERSEN
HAS AN AUTOMOTIVE
TITLE JUST RIGHT
FOR YOU!

- HOT ROD
- CAR CRAFT
- MOTOR TREND
- 4-WHEEL & OFF-ROAD
- CIRCLE TRACK
- MOTORCYCLIST
- DIRT RIDER

PETERSEN
We Build Magazines Right

AT YOUR
LOCAL
NEWSSTAND

PETERSEN'S 4WHEEL & OFF-ROAD

Takes You Where You Want To Go!

Hills, mud, water, sand, ice—nothing stops an off-road driver from going where he wants to go . . . and 4WHEEL & OFF-ROAD makes sure you get there!

Every month America's most popular off-road magazine shows you how-to winch your way out of tight spots while also providing challenging on and off-road test of 4 x 4's of all shapes and sizes, as well as features detailing the success of other drivers and how they made their vehicles invincible. All this, coupled with expert advice on cost-cutting tips that won't dent your budget, makes 4WHEEL & OFF-ROAD a vital tool you can't drive without!

And nothing can keep 4WHEEL & OFF-ROAD from taking you to the big events! Our writers travel far and wide filing reports from Gravelrama in Ohio and Mud Marathons in Missouri to the Score Championships in California and The Baja One Thousand in Mexico. 4WHEEL & OFF-ROAD—Takes You Where You Want To Go!

TRANS BULLETPROOFING
4WHEEL & OFF-ROAD
FORD FEVER!
BRONCO II PREVIEW

Now On Sale At Your Local Newsstand

pattern: on the center electrode, the discoloration should extend about .025-inch from the tip; the heat marks on the ground electrode should end somewhere on its curved portion; and discoloration on the cleaned portion of the threads should extend to the third thread from the tip.

Examples

Probably the best way to see how these factors affect which spark plug is right for an engine is to look at a couple of examples. Both hypothetical engines we're considering are 410-cubic-inch small-blocks—but everything applies to smaller engines in the exact same way.

1. Iron heads set up for 14mm gasket seat plugs with ¾-inch reach (pre-1971-design heads); 12:1 compression ratio; gasoline fueled; magneto ignited; wing set for high downforce; car is to race on short tracks. The short track means combustion chamber temperatures will rise and fall as the car continually accelerates and decelerates. This engine might take advantage of a power tip spark plug's temperature-handling characteristics, if piston and valve clearances allow. The magneto might suffer damage by using resistor plugs.

The Autolite heat range chart shows the coldest non-resistor power tip plug with the right physical dimensions to be Autolite #72. Assuming your earlier physical-dimensions check showed that a power tip plug would clear everything, this would be the plug to use to start testing. Here's how these factors might work together:

Though 12:1 compression is not especially high, gasoline burns hotter than alcohol; that, and the heavy downforce/load will cause high combustion chamber temperatures. Autolite #72, or one very near it in heat range, may well prove the right plug for this engine.

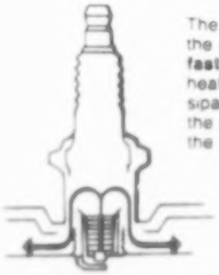
2. Aluminum heads machined for 14mm gasket seat plugs; ¾-inch reach; 15:1 compression ratio, alcohol fueled; magneto ignition; wing set for moderate downforce; car is to run on long tracks. Since alcohol burns cooler than gasoline, T356 aluminum carries off heat three times as fast as cast iron, and the wing isn't adding as

How is Heat Range Engineered?

Heat is conducted away from the firing tip through the (1) insulator to (2) the spark plug shell to (3) the cylinder head.

Thus, heat ranges are primarily controlled by the length of the insulator through which the heat must travel before escaping to the cylinder head.

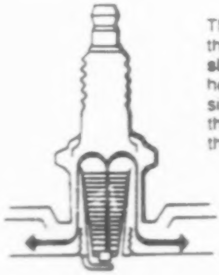
Other factors affecting Heat Range are the thermal characteristics of the insulator and the bond of the insulator to the shell.



The **shorter** the path, the **faster** the heat is dissipated and the **cooler** the plug.

Heavy Loads, High Speeds

SHORT Insulator Tip
Fast Heat Transfer
LOWER Heat Range
COLD PLUG



The **longer** the path, the **slower** the heat is dissipated and the **hotter** the plug.

Short Trip, Stop-and-Go

LONG Insulator Tip
Slow Heat Transfer
HIGHER Heat Range
HOT PLUG

much of a load as if it were angled fully down, a hot plug may be required to keep tips from fouling. But there are other factors at work here: the 15:1 compression ratio and the high-turbulence design of the combustion chambers. Both tend to heat spark plugs, especially the high compression. Again, it's safer to start testing with the coldest plug of the proper family.

Because this car is to be raced on long tracks, the driver will be on the gas almost constantly—a situation that tends to erode power tip plugs. Autolite #2593 is the coldest spark plug in the appropriate standard-tip family. It would be the right starting point to begin searching for the ideal plug.

■ Good Reading

Once you've found the right spark plugs for your engine, they can be a handy diagnostic tool, just as in passenger cars. But there are some differences.

Gray or Tan Tint: A mildly gray or tan tint on the insulator tips is normal for spark plugs being used with gasoline, if properly matched to the engine.

Heat Discoloration: Coloration won't be as evident with alcohol; all you'll have to go by are the heat marks—which also apply when using gasoline. As mentioned before, if they extend no more than .025-inch on the center electrode, nor past the bend on the ground electrode, nor past the third thread, everything is as it should be.

If in track testing after determining your ideal spark plug on the dyno, most plugs fit this description but one or two look hotter, the port nozzles on those cylinders are probably too lean, and must be richened. If all appear hot, your next move would be to put in a new set of the same plugs and change the fuel return setting to richen the mixture.

Carbon Fouling: This condition shows up as a black, sooty coating on the spark plug, and is often caused by overly rich mixtures. Using spark plugs that are too cold, or extensive low-speed driving can also bring it on. Extensive low-speed racing? Ever get caught under an extended yellow flag or have to run extra pace laps?

Before switching to a hotter plug, be sure a too-cold plug is the reason for your fouling problem. If it's not, the new plug may be too hot; it might then cause preignition problems.

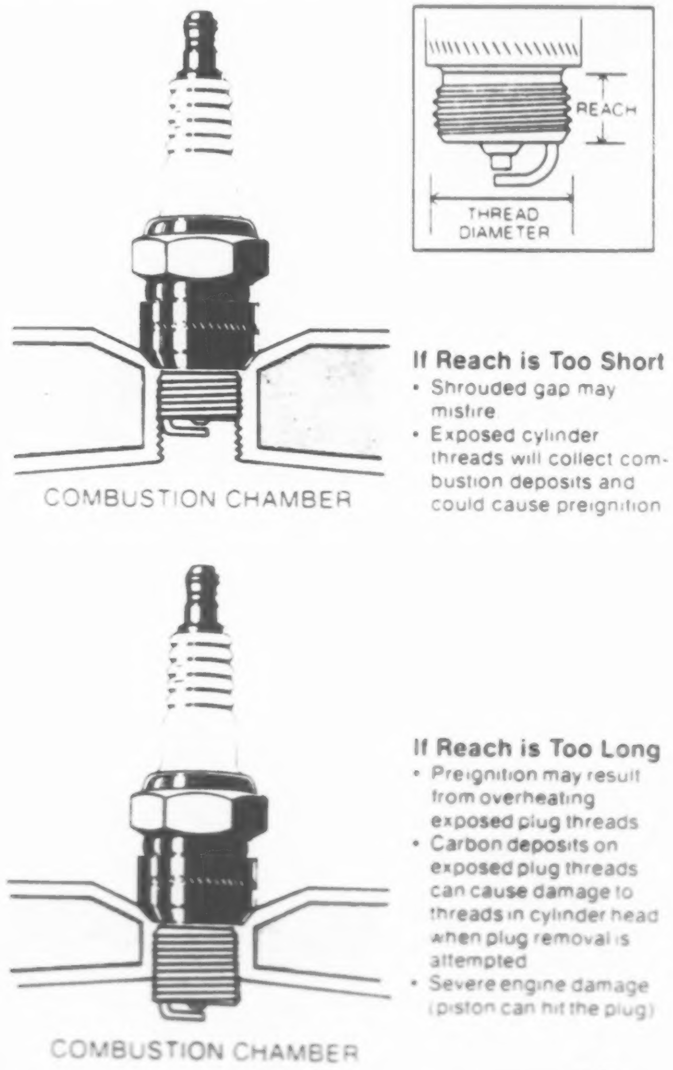
Fuel Fouling: The electrodes and insulator tips are wet with fuel on a fuel-fouled plug; chances are it will also smell of gasoline or alcohol. The insulator is often dark-tinted if fouled with gasoline; although wet, an alcohol-fouled plug usually looks new. A fuel-fouled plug indicates a cylinder not firing or an overly rich mixture.

Parade laps or extended idling in the pits can lead to fuel fouling if the spark plugs aren't hot enough. Unchecked, fuel fouling can dilute your oil, leading to engine wear.

Oil Fouling: An oil-fouled spark plug tip usually looks black and greasy. Oil fouling can also show up as a heavy gray/black ash buildup on the side electrode or on one side of the insulator tip. Such a plug is most often telling you something is seriously wrong: rings may be broken, cylinders scored, or valve guides shot. One exception: there may be oil fouling in newly rebuilt engines if the rings have not properly seated. In some cases, the rings just need time to seat. This is especially true if chrome rings are being used.

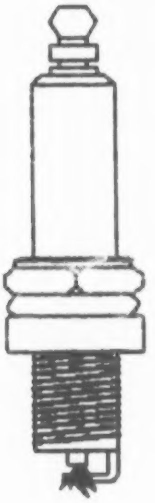
Detonation: This condition will physically damage the spark plug. If nothing is done about it, it will also damage the engine. Signs of detonation include a badly worn insulator tip, or a tip with pieces that have been blown or chipped away. Retarding ignition timing, switching to a higher-octane fuel, enriching the mixture, and switching to colder plugs are all possible means of dealing with detonation.

Preignition: This has engine-destroying effects similar to detonation, but it works faster. Burnt or melted electrodes are a sure sign of preignition; unfortunately, they might also indicate more extensive engine damage. Often—if there hasn't been any other damage—simply switching to a colder plug will take care of the problem. Sometimes, you must also retard ignition timing, or richen the fuel/air mixture.


REACH
THREAD DIAMETER
If Reach is Too Short
• Shrouded gap may misfire
• Exposed cylinder threads will collect combustion deposits and could cause preignition
COMBUSTION CHAMBER
If Reach is Too Long
• Preignition may result from overheating exposed plug threads
• Carbon deposits on exposed plug threads can cause damage to threads in cylinder head when plug removal is attempted
• Severe engine damage (piston can hit the plug)
COMBUSTION CHAMBER

ILLUSTRATIONS COURTESY OF AUTOLITE

Spark Plug Removal and Installation



Spark Plug Removal and Installation

After the normal service life of a spark plug, one or more of the plugs may be a little difficult to loosen. Allowing the engine ample cool-down time will facilitate plug removal. The use of penetrating oil is also recommended if the plug appears to be dangerously tight. Apply steady pressure with a plug wrench until the plug loosens. Before removing the plug, blow any dirt from the port area that might be present to prevent it from falling into the combustion chamber.

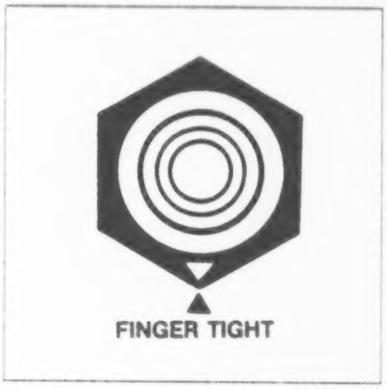
If the plug appeared to be overly-tight when removed by hand, it may be due to carbon collection in the threaded area of the cylinder head. This condition is more common in older engines. The threads should be cleaned with a chaser tool, and the seat wiped clean to assure good seat contact before installing a new plug.

Install the new plug fingertight, and complete the installation with a plug wrench. A gasket type plug will require about one-quarter (1/4) turn to effect a gas-tight seal. Tapered seat plugs do not use gaskets and require about one-sixteenth (1/16) turn.

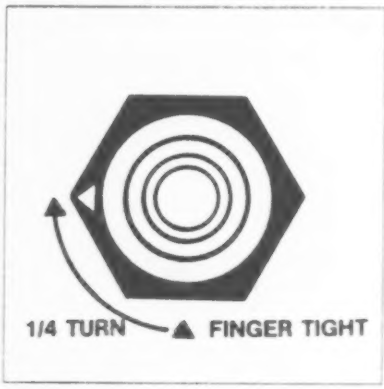
Use the Champion torque recommendation as a guide for tightening all spark plugs.

GASKET TYPE PLUGS

Thread plug into cylinder head by hand

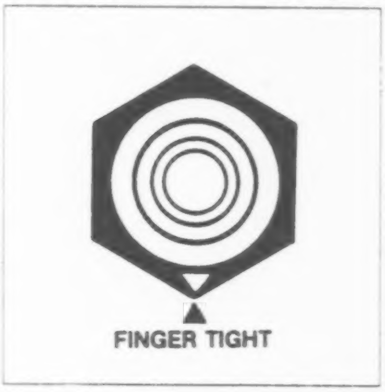


Tightening with socket wrench

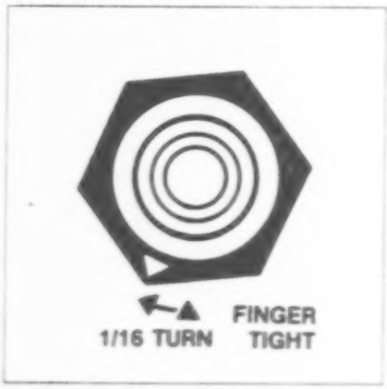


TAPERED SEAT PLUGS

Thread plug into cylinder head by hand



Tightening with socket wrench



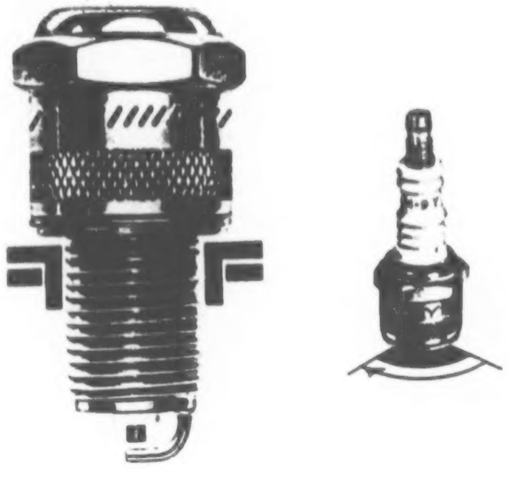
TORQUE RECOMMENDATIONS

Spark Plug Thread Size	Cast Iron Heads		Aluminum Head	
	w/Torque Wrench	w/o Torqe Wrench	w/Torque Wrench	w/o Torque Wrench
Gasket Type				
10mm	8-12 lb.ft.	1/4Turn	8-12 lb.ft.	1/4 Turn
12mm	10-18 lb.ft.	1/4Turn	10-18 lb.ft.	1/4 Turn
14mm	26-30 lb.ft.	1/4 to 1/8 Turn	18-22 lb.ft.*	1/4 Turn
18mm	32-38 lb.ft.	1/4Turn	28-34 lb.ft.	1/4 Turn
7/8"	50-55 lb.ft.	1/4Turn	—	—
TAPERED SEAT				
14mm	7-15 lb.ft.	1/16 Tun (Snug)	7-15 lb.ft.	1/16 Turn (Snug)
18mm	15-20 lb.ft.	1/16 Tun (Snug)	15-20 lb.ft.	1/16 Turn (Snug)

*Mazda Rotary Engine requires only 8-13 lb.ft. (1/4 Turn).

CHAMPION

CORRECT PLUG INSTALLATION



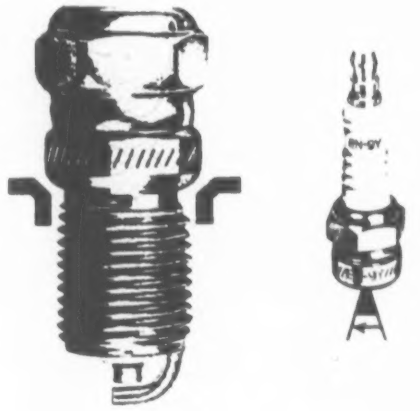
Gasket seat

Plugs with a seating gasket need to be installed 'finger tight' followed by a maximum of a quarter turn with the plug spanner.

Further tightening will not improve the sealing properties of the gasket.

Excessive tightening may damage plug hole threads in aluminium cylinder heads.

Remember to remove all particles of grit from the gasket and seating area before installing a spark plug.



Taper seat

14 mm and 18 mm gasketless taper seat plugs need special care with installation to **avoid overtightening.**

If too much torque is applied during installation of this type, the interlocking action of the conical faces can make removal very difficult – if not impossible.

Having made sure that the seating area is perfectly clean, the **plug should be screwed in 'finger tight' and then gently tightened with the plug spanner, by a maximum of 1/16th of a turn.**

ACCESSORIES

CT-483 taper seat torque wrench

To underline the necessity for care in the installation of taper seat spark plugs, Champion have developed the CT-483 torque wrench. This torque wrench is pre-set to the requisite 8 – 12lb/ft thus protecting the cylinder head from the damage often associated with over-tightened spark plugs. The wrench is available either as a single unit (Part no. CT-483), or as a set (Part no. CT-483(S)) which comes complete with an extension bar and 5/8" AF socket featuring a rubber plug retaining insert. All are chromium finished and manufactured to the expected high Champion standards.

CT-436 firing indicator

A handy but effective way of checking the H.T. circuit for spark plug and ignition voltage conditions. Clips neatly in the pocket.

CHAMPION
CLÉ DYNAMOMÉTRIQUE
TORQUE WRENCH

CT-407 or CT-901 'Plug Mate' socket

The CT-407 'Plug Mate' is a high quality chrome finished 3/8" (9.5 mm) square drive socket, featuring a magnetic insert to aid easy installation of any 13/16" (21 mm) hexagon spark plug. An alternative to the CT-407 is the CT-901, featuring a rubber insert rather than a magnet. Both are ideally used in conjunction with the CT-451 or CT-900 ratchet handle.

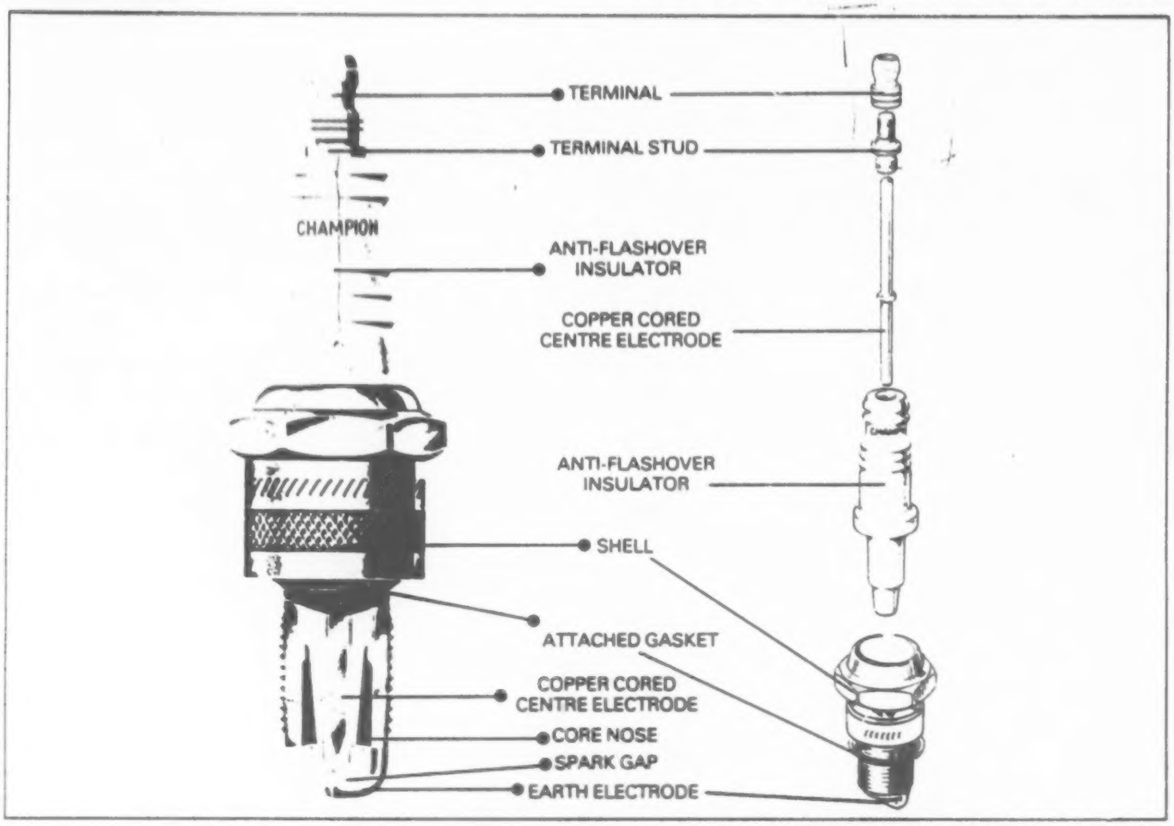
CT-451/CT-900 pivoting ratchet handle

A high quality chrome finished socket wrench featuring 3/8" (9.5 mm) square drive, a reversible ratchet and a 90° pivoting handle.

CT-910
Peugeot, Renault, Citroen
taper seat spark plugs

Set: CT-483(S)

CHAMPION ENGINEERED FEATURES


TERMINAL
TERMINAL STUD
CHAMPION
ANTI-FLASHOVER INSULATOR
COPPER CORED CENTRE ELECTRODE
ANTI-FLASHOVER INSULATOR
SHELL
ATTACHED GASKET
COPPER CORED CENTRE ELECTRODE
CORE NOSE
SPARK GAP
EARTH ELECTRODE

CROSS-REFERENCE LIST

Std.	▤	Std.	▤	Std.	▤	Std.	▤
N2	N2C	L7J	L82C	J11Y	J12YC	RJ18Y6	RJ18YC6
RN2	RN2C	RL7J	RL82C	RJ11Y	RJ12YC	RJ18Y8	RJ18YC8
N3	N3C	BL7Y	V9YC	RBL11Y	RV12YC	N63Y	N4YC
RN3	RN3C	RBL7Y	RV9YC	N11Y	N11YC	N64Y	N4YC
BL3	V4C	N7Y	N7YC	RN11Y	RN11YC	L77J	L77JC
BL4	V4C	RN7Y	RN7YC	RF12	RF10C	L77J4	L77JC4
J4	J6C	RBN7Y	RS7YC	J12Y	J12YC	QL77J4	QL77JC4
J4J	J6C	BN7Y	S7YC	RJ12Y	RJ12YC	L78	L78C
UJ4J	J6C	A8	A6YC	RJ12Y6	RJ12YC6	RL78	RL78C
RJ4	RJ6C	A8Y	A6YC	RBL12	RV12C	L81Y	L82YC
RJ4J	RJ6C	RA8Y	RA6YC	RBL12-6	RV12C6	UJ81J	UJ81C
N4	N4C	J8	J8C	N12Y	N12YC	UL81J	UL81C
RN4	RN4C	J8J	J8C	RN12Y	RN12YC	L82	L82C
N5	N5C	UJ8	J8C	RBN12Y	RS12YC	L82Y	L82YC
RN5	RN5C	RJ8	RJ8C	RBN12Y6	RS12YC6	RL82	RL82C
A6	A6YC	RJ8J	RJ8C	BL13Y	V12YC	L85	L82C
A6Y	A6YC	RBL8	RV8C	RBL13Y	RV12YC	RL86	RL82C
RA6	RA6YC	RBL8-6	RV8C-6	RBL13Y6	RV12YC6	L86	L86C
RA6Y	RA6YC	N8Y	N7YC	F14Y	F11YC	RL86	RL86C
J6	J6C	RBN9Y	RS9YC	RF14Y	RF11YC	L87Y	L87YC
J6J	J6C	BN9Y	S9YC	J14Y	J14YC	RL87Y	RL87YC
UJ6	J6C	BL9Y	V9YC	RJ14Y	RJ14YC	L88A	L86C
RJ6	RJ6C	RBL9Y	RV9YC	N14Y	N12YC	L92Y	L92YC
RJ6J	RJ6C	F9Y	F9YC	RN14Y	RN12YC	L286	L86C
N6	N5C	RF9Y	RF9YC	RN14Y6	RN12YC6	860	F10C
RN6	RN5C	N9Y	N9YC	RBL15Y	RV15YC	870	F11YC
N6Y	N6YC	RN9Y	RN9YC	RBL15Y4	RV15YC4		
RN6Y	RN6YC	F10	F10C	RBL15Y6	RV15YC6	CJ = T	
RBN6Y	RS6YC	RF10	RF10C	RBL15Y8	RV15YC8	RCJ = RT	
BN6Y	S6YC	J10Y	J12YC	N16Y	N16YC	DJ = B	
J7	J8C	RJ10Y	RJ12YC	RN16Y	N16YC	RDJ = RB	
J7J	J8C	N10Y	N9YC	RBL17Y	RV17YC	BL = V	
RJ7	RJ8C	RN10Y	RN9YC	RBL17Y6	RV17YC6	RBL = RV	
F7Y	F7YC	F11Y	F11YC	J18Y	J18YC	BN = S	
L7	L82C	RF11Y	RF11YC	RJ18Y	RJ18YC	RBN = RS	

CHAMPION

SPARK PLUG HEXAGON SIZES

Thread size	10 mm	12 mm		14 mm				18 mm			
Seating	Gasket	Gasket		Gasket			Taper	Gasket			Taper
First prefix or Combination	G, Y, Z	P	R, A	C	CJ	E, H, J, L, N	BL, BN, DJ, S, V	M	B, D	K	F
A/F size inches	5/8"	11/16"	11/16" or 3/4"	5/8"	3/4"	13/16"	5/8"	11/16" or 7/8"	7/8"	1"	13/16"
Metric mm	16 mm	18 mm	18 or 19 mm	16 mm	19 mm	21 mm	16 mm	18 or 23 mm	23 mm	26 mm	21 mm

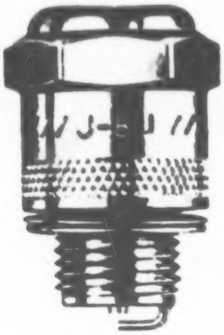


Fig. 1

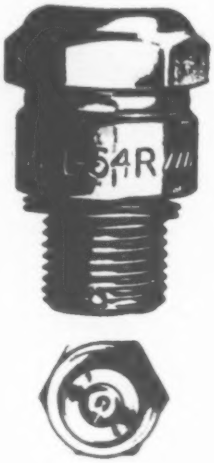


Fig. 2

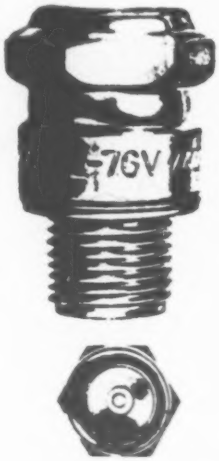


Fig. 3

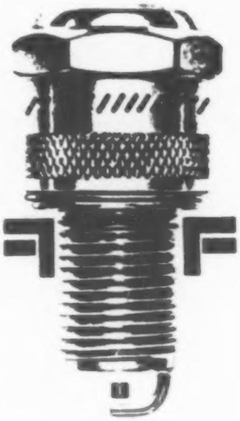


Fig. 4

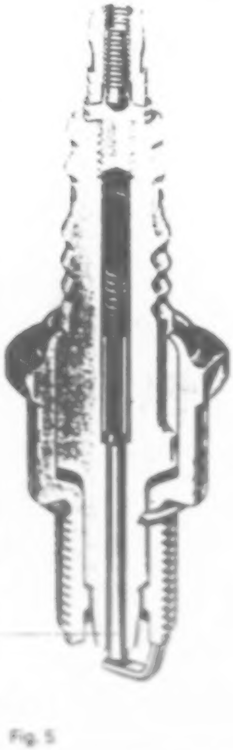


Fig. 5

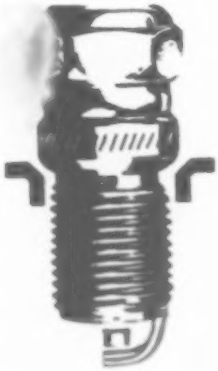


Fig. 6

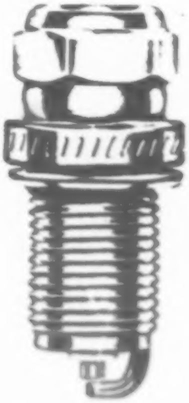


Fig. 7

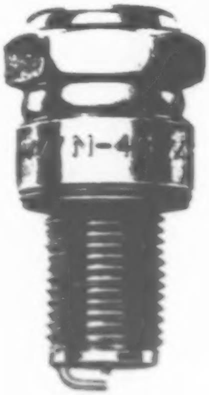


Fig. 8

Fig. 1 Cut back earth electrode
Fig. 2 Retracted gap type
Fig. 3 Surface gap type
Fig. 4 Projected core nose

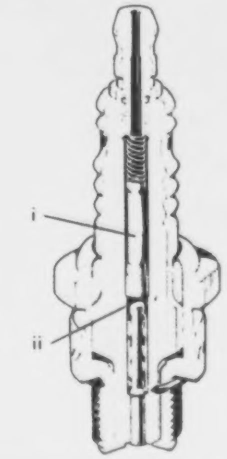
Fig. 5 Resistor type (sectioned)
Fig. 6 Taper seal
Fig. 7 14 mm × 3/4" reach × 5/8" hex
Fig. 8 Gold Palladium

SURFACE GAP TYPE

Examples:
J19V, L20V, L76V

This type is used with certain high energy capacitor discharge ignition systems – as recommended – to overcome the worst fouling problems without overheating. The spark is fired across the insulator surface between the centre electrode and the shell.

The example shown here is a QUL77V featuring (i) a Q type inductive suppressor and (ii) an auxiliary gap.



BANTAM TYPE

Examples:
CJ6, CJ8, DJ8J,
J17LM, Y82

Special purpose designs classified as 'Bantam' because of their short overall length. They are required to meet space limitations of small engines with compact cowling or shrouds in certain equipment such as chain saws, lawn mowers, etc.

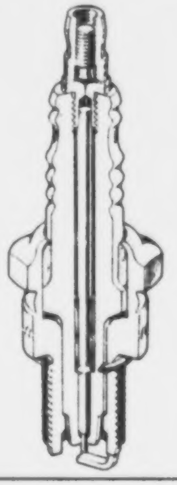
GOLD PALLADIUM TYPE

Champion have developed the Gold Palladium spark plug featuring a fine wire centre electrode for premium performance.

The design features of this plug type allow a smaller gap to be run than with conventional electrodes, as the spark masking effect is considerably reduced, thus aiding easier starting and eliminating the misfire often associated with small spark gaps.

The longer, slimmer core nose provides a greater shunt path distance to earth, and also a greater cavity volume between the core nose and plug shell allowing more efficient gas scavenging.

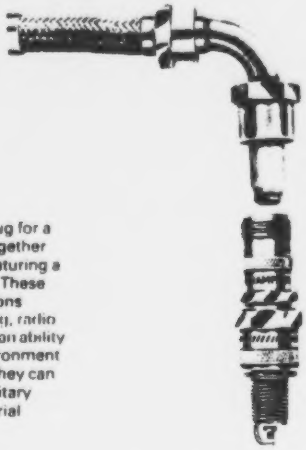
The Gold Palladium plug therefore offers easier starting, better protection against fouling and its effects and usually a longer service life.



SCREENED TYPE

Examples:
RSN12Y, RSN8,
RSN13P

Illustrated here is a spark plug for a screened ignition system together with a length of H.T. lead featuring a typical screened connector. These are for specialised applications requiring total waterproofing, radio interference suppression or an ability to work in a hazardous environment such as flammable gases. They can be found particularly on military vehicles, marine and industrial applications.



SURFACE GAP TYPE PLUGS

Surface gap type plugs have no effective heat range as such but are placed in the coldest area of a heat range chart.

	Standard	RFI suppressed
∅ 10 mm × 19 mm (³/₄")	G54V	
∅ 12 mm × 12.5 mm (.492")	UP77V*	
∅ 14 mm × 9.5 mm (³/₈")	UJ17V*, J19V	
∅ 14 mm × 12.7 mm (¹/₂")	UL17V*, UL18V*, L20V, L76V, UL77V*, L78V	QL76V QUL77V* QL78V
∅ 14 mm × 11.7 mm (.460") Taper seat	BL21V	
∅ 14 mm × 19 mm (³/₄")	N19V, UN19V*	QN19V
∅ 18 mm × 11.3 mm (.445")	UK16V*, D77V	

384

*Auxiliary gap

Sales Symbols

The sales symbol on a spark plug is composed of a basic "Heat Range" number with prefix letters and suffix letters / numbers to identify major features of the plug design. The following charts contain a detailed description of the Champion Sales Symbols.

SECOND OR THIRD PREFIX

Letter	Description	
B	Standard Height	See below for combinations
C	Bantam Height	
D	Bantam Height	
E	Shielded 5/8"—24	
G	1"—20 Female Connector	
H	Shielded 3/4"—20	
K	Resistor	
M	Shielded 5/8"—24 Ordnance	
Q	Resistor—CDI	
R	Resistor	
S	Shielded 11/16"—24 Whitworth	
T	13/16"—20 Thread Above HEXAGON	
U	Auxiliary Gap	
V	Shielded 1"—20	
X	Resistor	
Z	Long Reach, Half-Thread	

FIRST PREFIX

Letter	Thread Size	Reach	Hex
A	12mm	3/4"	11/16" or 18mm
B	18mm	13/16"	7/8"
C	14mm	3/4"	5/8"
D	18mm	1/2"	7/8"
E	14mm	.708" Half Threaded	5/8"
F	18mm	.460" Taper Seat	13/16"
G	10mm	.750"	5/8"
H	14mm	7/16"	13/16"
J	14mm	3/8"	13/16"
K	18mm	All	1"
L	14mm	1/2" or .472 "	13/16"
M	18mm	1/2"	7/8" or 11/16"
N	14mm	3/4"	13/16"
P	12mm	.492"	11/16"
R	12mm	3/4"	3/4" or 11/16"
S	14mm	.708" Taper Seat	5/8"
U	18mm	1-1/8"	7/8"
V	14mm	.460" Taper Seat	5/8"
W	7/8"-18	All	15/16" or 1"
Y	10mm	1/4"	5/8"
Z	10mm	.492"	5/8"

*With Extended Skirt

COMBINATION PREFIX

Letters	Thread Size	Reach	Hex
BL or V	14mm	.460" Taper Seat	5/8"
BN or S	14mm	.708" Taper Seat	5/8"
CJ	14mm	3/8"	3/4" or 13/16"
DJ	14mm	.325" Taper Seat	5/8"
FN or C	14mm	.750" w/gasket	5/8"

COMBINATION SUFFIX

Letters	Thread Size	Reach	Hex
BY	Multiple Ground Electrode with Projected Core Nose		
CM	14mm (Special for Mopeds)	.472"	13/16"
GY	Fine Wire (Semi-precious Electrode) with Projected Core Nose		
LM	14mm (Special for Lawnmowers)	3/8"	13/16"
LY	Extended Electrode Gap and Core Nose Projection		

R V 15 Y C 4

BASIC NUMBER (Heat Range & Application)

Heat Range Reference Number	Description
1 to 25	Automotive, Small Engine and Ordnance
26 to 50	Aviation
51 to 75	Competition, Racing
76 to 99	Industrial & Special Applications

FIRST OR SECOND SUFFIX

Letter	Description
None or A	Conventional
B	Two Ground Electrodes
C	Copper Plus Design
D	Protruding Nose, Round Ground Electrode
F	Three Ground Electrode
G	Fine Wire—Semi-Precious Electrode
J	Cutback Ground Electrode, Includes Modified Gap
L	Skirted Shell Firing End With Extended Gap
N	Four Ground Electrode
P	Fine Wire—Platinum Electrode
R	Push Wire
S	Single Ground Electrode at Side of Center Electrode
V	Surface Gap
Y	Projected Core Nose

NUMERIC SUFFIX

Number	Description
4	Indicates special production
5	wide gaps required
6	to meet Federal and
8	California requirements.

The sales symbol is composed of a "Heat Range" Reference together with prefix letters and suffix letters/numbers to indicate major features of the plug design. Each has a definite meaning. Heat range reference indicate a general application category (automotive, aviation, competition, special feature or application) of the plug design.

UNIT 13 - OUTBOARD FUEL AND OIL SYSTEMS

MODULE 13.01

REPAIRING FUEL AND OIL DELIVERY SYSTEMS INSTRUCTOR GUIDE

COMPETENCY:

1. Identify fuel and oil system components.
2. Troubleshoot, and repair, the following outboard engine fuel and oil delivery system components:
   - fuel tanks
   - fuel lines
   - fuel pump
   - oil injection system
   - fuel enricher

INSTRUCTIONAL OBJECTIVES:

The student will be able to:

1. Identify the parts of built-in and portable fuel tanks.
2. Recognize materials commonly used in fuel tank construction.
3. Explain the relationship between engine horsepower, fuel demand, and fuel line diameter requirements.
4. State the method by which fuel line approved for marine use may be identified.
5. Recognize and use the various types of fuel and oil hose clamps.
6. Recognize various types of marine-use fuel filters.
7. Identify the parts of a fuel line primer ball.
8. Choose the appropriate location for and then install a fuel line primer ball.
9. Look up the regulations pertaining to the following fuel system components and related items:
   - fuel lines and hoses
   - fuel tank construction
   - fuel tank location and installation
   - fuel fittings
   - bilge vents and blowers
10. Recognize outboard motor fuel pumps and identify their components.
11. Explain the mechanism by which outboard motor fuel pumps operate.
12. Explain the mechanism by which fuel is delivered to the carburetors on outboard motors.
13. Identify the effects of fuel restrictions on outboard motors.
14. State one common problem with fuel tank antisiphon valves.
15. Use a fuel pressure gauge to detect restrictions in fuel lines and make the repairs necessary to eliminate the restrictions.
16. Test fuel and oil lines for air intrusion.
17. Use a fuel pressure gauge to detect defective fuel pumps.
18. Repair fuel pumps by installing repair kits.
19. Identify outboard motor oiling systems.
20. Explain the mechanism by which outboard motor oil injection systems

operate.
21. Test oil injection systems and make necessary repairs.
22. Repair fuel and oil systems which have been contaminated with water.
23. Apply the preventative maintenance procedures necessary to prevent water contamination in fuel and oil systems.
24. Test and repair fuel enricher system.
25. Test and repair fuel and oil warning systems.

LEARNING ACTIVITIES:

1. Participate in class lectures and discussion. (Objectives 1 - 25)
2. Read about boat compartment ventilation requirements in the NMMA Certification Handbook on page 19. (Objective 9)
3. Read about permanent fuel system requirements in the NMMA Certification Handbook on page 22. (Objective 9)
4. Read about fuel and oil system troubleshooting and repair in the service manuals found in the shop. Select a manual for a small engine, a mid-size engine, and a large engine. Compare the procedure for each. (Objectives 1 - 25)
5. Observe the following demonstration:
   Troubleshooting Fuel Systems With a Pressure Gauge
   (Objective 15, 17)
6. Use troubleshooting techniques to detect defective fuel and oil delivery system components on engines in the shop. (Objectives 15 - 17, 21, 24, 25)
7. Make repairs to defective fuel and oil systems on engines in the shop. (Objectives 8, 18, 22 - 25)

EVALUATION/CHECK-OUT:

You will be given opportunities to troubleshoot and repair fuel and oil systems. The instructor will evaluate your ability to locate faulty components and make the necessary repairs. Your performance will be recorded on the Repairing Fuel and Oil System Performance Checklist.

RESOURCES:

LEARNING MATERIALS:

1. Reference
   1986 NMMA Certification Handbook
   National Marine Manufacturer's Association
   401 North Michigan Avenue
   Chicago, IL 60611

2. Reference
   Copies of various manufacturer's service manuals for low, medium, and high horsepower model.

EQUIPMENT:

MODULE 13.01

1. Engines for demonstrating the use of the fuel pressure gauge.
2. Fuel pressure gauge and accessories.
   (Refer to the Tools section of this document for specifications.)
3. Student tool kits.
   (Refer to the Tools section of this document for specifications.)
4. Live work or bugged engines for students to practice troubleshooting and repair techniques. If live work will be used try to plan ahead and arrange for engines to be brought in.

AUDIO VISUAL MATERIALS:

(none used)

NAME________________________ STUDENT NO.________________________

13.01 **PERFORMANCE CHECKLIST** 1 of 6

MODULE : REPAIRING FUEL AND OIL DELIVERY SYSTEMS

COMPETENCY: Identify Fuel and Oil System Components

1. ☐ Named parts of portable fuel tanks
2. ☐ Named parts of built-in fuel tanks
3. ☐ Identified common fuel tank construction materials
4. ☐ Identified fuel pumps
5. ☐ Named parts of fuel pump
6. ☐ Identified fuel and oil lines
7. ☐ Named parts of primer ball
8. ☐ Identified oil injection system
9. ☐ Named parts of oil injection system
10. ☐ Explained fuel pump operation
11. ☐ Explained oil injection system operation
12. ☐ Identified fuel enricher system
13. ☐ Named fuel enricher system components
14. ☐
15. ☐

COMPETENCY ACHIEVED? ☐ **YES** ☐ **NO**

EXPLANATION:

NAME________________________ STUDENT NO.________________________

13.01 **PERFORMANCE CHECKLIST** 2 of 6

MODULE : REPAIRING FUEL AND OIL DELIVERY SYSTEMS

COMPETENCY: Troubleshoot and repair fuel tanks

1. ☐ Used fuel pressure gauge to detect restriction in tank
2. ☐ Tested fuel tank vent
3. ☐ Tested antisiphon valve in built-in fuel tank
4. ☐ Tested tank fittings and connectors for air intrusion
5. ☐ Tested fuel pickup in tank
6. ☐ Repaired fuel tank vent
7. ☐ Repaired /replaced antisiphon valve
8. ☐ Repaired/replaced fuel tank fittings
9. ☐ Tested fuel level sender
10. ☐ Repaired/replaced fuel level sender
11. ☐ Checked fuel system for water contamination
12. ☐ Purged fuel system of water and other contaminants
13. ☐
14. ☐
15. ☐

COMPETENCY ACHIEVED? ☐ **YES** ☐ **NO**

EXPLANATION:

NAME____________________________ **STUDENT NO.**____________________________

13.01 **PERFORMANCE CHECKLIST** 3 of 6

MODULE : REPAIRING FUEL AND OIL SYSTEMS

COMPETENCY: Troubleshoot and repair fuel lines

1. ☐ Examined fuel lines and fittings for cracks and leaks
2. ☐ Tested for fuel line restrictions with pressure gauge
3. ☐ Examined fuel filter for contamination
4. ☐ Tested fuel filter with fuel pressure gauge
5. ☐ Examined primer ball for cracks and leaks
6. ☐ Tested fuel lines for air intrusion
7. ☐ Selected and replaced fuel lines
8. ☐ Selected and replaced fuel filters
9. ☐ Selected and replaced fuel primer ball
10. ☐
11. ☐
12. ☐
13. ☐
14. ☐
15. ☐

COMPETENCY ACHIEVED? ☐ **YES** ☐ **NO**

EXPLANATION:

NAME________________________ **STUDENT NO.**________________________

13.01	**PERFORMANCE CHECKLIST**	4 of 6

MODULE : REPAIRING FUEL AND OIL SYSTEMS

COMPETENCY: Troubleshoot and repair fuel pump

1. ☐ Examined fuel pump fuel screen for contamination
2. ☐ Selected and replaced fuel pump fuel screen
3. ☐ Tested input side of fuel pump with pressure gauge
4. ☐ Tested output side of fuel pump with pressure gauge
5. ☐ Examined fuel pump for cracks and leaks
6. ☐ Tested fuel pumps for air intrusion
7. ☐ Removed and disassembled fuel pump
8. ☐ Selected and replaced fuel pump check valves
9. ☐ Selected and replaced fuel pump diaphragm
10. ☐ Selected fuel pump gasket kit
11. ☐ Installed fuel pump
12. ☐
13. ☐
14. ☐
15. ☐

COMPETENCY ACHIEVED? ☐ **YES** ☐ **NO**

EXPLANATION:

NAME____________________________ **STUDENT NO.**____________________________

13.01 **PERFORMANCE CHECKLIST** 5 of 6

MODULE : REPAIRING FUEL AND OIL SYSTEMS

COMPETENCY: Troubleshoot and repair oil injection

1. ☐ Examined remote oil tank for contamination
2. ☐ Examined remote tank oil filter for contamination
3. ☐ Checked oil lines for cracks, kinks, and leaks
4. ☐ Checked oil lines and tank fittings for cracks and leaks
5. ☐ Examined oil reservoir for contamination
6. ☐ Tested oil pump output
7. ☐ Removed contamination from oil tanks an lines
8. ☐ Selected and replaced oil filter
9. ☐ Selected and replaced oil lines
10. ☐ Selected/replaced oil pump
11. ☐ Tested oil level warning system
12. ☐ Selected/replaced warning horn
13. ☐ Selected/replaced oil level senders
14. ☐ Selected and replaced oil pump motion detector
15. ☐

COMPETENCY ACHIEVED? ☐ **YES** ☐ **NO**

EXPLANATION:

NAME________________________ **STUDENT NO.**________________________

13.01 **PERFORMANCE CHECKLIST** 6 of 6

MODULE : REPAIRING FUEL AND OIL SYSTEMS

COMPETENCY: Troubleshoot and repair fuel enricher

1. ☐ Checked enricher hoses and fittings for cracks and leaks
2. ☐ Checked operation of enricher valve solenoid
3. ☐ Checked enricher crankcase nipples
4. ☐ Tested input side of enricher valve
5. ☐ Selected/replaced enricher hoses
6. ☐ Selected and replaced enricher valve and solenoid
7. ☐ Cleared obstructed enricher crankcase nipples
8. ☐
9. ☐
10. ☐
11. ☐
12. ☐
13. ☐
14. ☐
15. ☐

COMPETENCY ACHIEVED? ☐ **YES** ☐ **NO**

EXPLANATION:

MODULE 13.02

REPAIRING CARBURETORS AND EFI — INSTRUCTOR GUIDE

COMPETENCY:

1. Troubleshoot and repair carburetors.
2. Troubleshoot and repair electronic fuel injection system.

INSTRUCTIONAL OBJECTIVES:

The student will be able to:

1. Name the parts found in outboard motor carburetor assemblies.
2. Explain the principles of operation of outboard engine carburetors.
3. Inspect carburetors for contamination.
4. Remove and disassemble outboard engine carburetors.
5. Rebuild outboard engine carburetors.
6. Install, adjust, and synchronize outboard engine carburetors.
7. Adjust the idle circuit in fixed jet carburetors.
8. Name the parts found in an outboard motor electronic fuel injection assembly.
9. Explain the principles of operation of outboard engine electronic fuel injection.
10. Troubleshoot electronic fuel injection systems.
11. Inspect electronic fuel injection system for contamination.
12. Remove and disassemble outboard engine electronic fuel injection system.
13. Replace defective components in outboard engine electronic fuel injection systems.
14. Install, adjust, and synchronize outboard engine electronic fuel injection systems.

LEARNING ACTIVITIES:

1. Participate in class lectures and discussions.
   (Objectives 1 - 14)
2. Locate the "Theory of Operation" section for carburetors in a service manual for a small, mid-size, and a large outboard motor. Read about carburetor principles of operation in each of the service manuals you have selected. Also read about theservice procedures for each.
   (Objectives 1 - 7)
3. Observe a demonstration of carburetor removal, disassembly, reassembly, adjustment, and synchronization.
   (Objectives 1 - 7)
4. Practice removing, repairing, and replacing carburetors on projects in the shop.
   (Objectives 1 - 7)
5. Locate the "Electronic Fuel Injection" in a Mercury Marine service manual which covers fuel injection. Read about fuel injection principles of operation. Also read about the electronic fuel injection service procedures and pay particular attention to the use of any

test equipment.
(Objectives 9 - 14)

6. Observe the following demonstrations:
   Troubleshooting EFI With the EFI Tester
   EFI Removal, Disassembly, Reassembly, Adjustment, and Synchronization
   (Objectives 10 - 14)
4. Practice using EFI test equipment and troubleshooting procedures on a motor in the shop which has electronic fuel injection.
   (Objectives 10 - 14)

EVALUATION/CHECK-OUT:
You will be given opportunities to troubleshoot and repair carburetors and fuel injection systems. The instructor will evaluate your ability to locate carburetor and fuel injection trouble and make the necessary repairs. Your performance will be recorded on the Repairing Carburetors and EFI Performance Checklist.

RESOURCES:

LEARNING MATERIALS:
1. Reference
   Copies of various manufacturer's service manuals for a low, a medium, and a high horsepower model. Also a copy of Mercury Marine service manual which cover electronic fuel injection.

EQUIPMENT:
1. Engines for demonstrating carburetor removal, disassembly, reassembly, installation, adjustment and synchronization.
2. An engine equipped with electronic fuel injection for demonstrating EFI troubleshooting techniques.
3. Electronic fuel injection test equipment.
   (Refer to the Tools section of this document for specifications.)
3. Student tool kits.
   (Refer to the Tools section of this document for specifications.)
4. Live work or bugged engines for students to practice troubleshooting and repair techniques. If live work will be used try to plan ahead and arrange for engines to be brought in.

AUDIO VISUAL MATERIALS:
(none used)

NAME________________________ **STUDENT NO.**________________________

13.02	**PERFORMANCE CHECKLIST**	1 of 2

MODULE : REPAIRING CARBURETORS AND EFI

COMPETENCY: Troubleshoot and repair carburetors

1. ☐ Identified carburetor parts
2. ☐ Explained how carburetor works
3. ☐ Removed carburetors from engine
4. ☐ Disassembled carburetor
5. ☐ Installed carburetor rebuild kit
6. ☐ Adjusted float level
7. ☐ Reassembled carburetors
8. ☐ Installed carburetors on engine
9. ☐ Synchronized carburetors
10. ☐ Adjusted low, and high speed circuits when applicable
11. ☐ Resized fixed jet in idle circuit to set correct idle when applicable
12. ☐
13. ☐
14. ☐
15. ☐

COMPETENCY ACHIEVED? ☐ **YES** ☐ **NO**

EXPLANATION:

NAME_______________________ **STUDENT NO.**_______________________

13.02	**PERFORMANCE CHECKLIST**	2 of 2

MODULE : REPAIRING CARBURETORS AND EFI

COMPETENCY: Troubleshoot and repair electronic fuel injection

1. ☐ Recognized and named EFI components
2. ☐ Explained EFI basic operation
3. ☐ Recognized and selected EFI test equipment
4. ☐ Used service manual and EFI tester to find trouble
5. ☐ Replaced faulty EFI components
6. ☐ Adjusted and synchronized EFI system
7. ☐
8. ☐
9. ☐
10. ☐
11. ☐
12. ☐
13. ☐
14. ☐
15. ☐

COMPETENCY ACHIEVED? ☐ **YES** ☐ **NO**

EXPLANATION:

UNIT 14 - OUTBOARD POWERHEAD ELECTRICAL AND STARTING SYSTEMS

MODULE 14.01

REPAIRING CHARGING SYSTEMS **INSTRUCTOR GUIDE**

COMPETENCY:
Troubleshoot and repair outboard engine charging system components.

INSTRUCTIONAL OBJECTIVES:

The student will be able to:
1. Recognize and name charging system components.
2. Test a bridge rectifier using an ohmmeter.
3. Detect open and shorted charging system wires.
4. Test voltage regulators using an ammeter.
5. Find faulty stators and lighting coils using an ohmmeter or peak reading voltmeter.
6. Remove and replace defective charging system components.
7. Test batteries.

LEARNING ACTIVITIES:
1. Participate in class lectures and discussions.
   (Objectives 1 - 7)
2. Locate the service manual for a low horsepower, mid-range horsepower, and a large horsepower engine. Find the charging system section in each and read about how it works and how to troubleshoot it.
   (Objectives 1 - 7)
3. Observe the following demonstrations:
   - Checking Bridge Rectifiers
   - Checking Stator Output and Resistance
   - Testing Battery Cables and Batteries
   - Checking Voltage Regulators.
   - Removing Charging System Components

   (Objectives 1 -7)
4. Read Chapter 2, Understanding the Battery, in "Your Boat's Electrical System", p31.
   (Objectives 1 and 7)
5. Practice troubleshooting charging systems on engines in the shop.
   (Objectives 1 - 7)

EVALUATION/CHECK-OUT:
You will be given opportunities to repair defective charging systems on engines that are brought into the shop. Your ability to use troubleshooting techniques to locate defective components and then to replace or repair them will be evaluated. Your performance will be recorded on the Repairing Charging Systems performance checklist.

RESOURCES:

MODULE 14.01

LEARNING MATERIALS:

1. Reference
   Manufacturer's service manuals.

2. Reference
   "Your Boat's Electrical System"
   Conrad Miller
   1988, The Hearst Corporation
   ISBN 0-688-08132-0

EQUIPMENT:

1. Outboard engines equipped with charging systems and batteries.
2. Student basic tool kit.
3. Voltmeter.
4. Ohmmeter.
5. Ammeter.
6. Peak reading voltmeter, (CD-77 or DVA).
7. Battery Hydrometer.
8. Battery load tester.

AUDIO VISUAL MATERIALS:

(none used)

NAME______________________________ **STUDENT NO.**______________________________

14.01 **PERFORMANCE CHECKLIST**

MODULE : REPAIRING CHARGING SYSTEMS

COMPETENCY: Troubleshoot and repair outboard engine charging system.

1. ☐ Identified defective battery using voltmeter
2. ☐ Identified defective battery using hydrometer
3. ☐ Identified defective battery using load tester
4. ☐ Set up battery on shop battery charger
5. ☐ Added water to battery electrolyte
6. ☐ Located defective stator using ohms check
7. ☐ Located defective stator using output test
8. ☐ Identified faulty rectifier with ohmmeter
9. ☐ Rigged engine for voltage regulator test
10. ☐ Identified bad voltage regulator using ammeter
11. ☐ Located shorted and open battery cables with ohmmeter
12. ☐ Recognized and named charging system parts
13. ☐
14. ☐
15. ☐

COMPETENCY ACHIEVED? ☐ **YES** ☐ **NO**

EXPLANATION:

MODULE 14.02

REPAIRING STARTING SYSTEMS **INSTRUCTOR GUIDE**

COMPETENCY:
Troubleshoot and repair starter, starter solenoid, starter key switch, and neutral safety devices.

INSTRUCTIONAL OBJECTIVES:

The student will be able to:
1. Recognize and name starting system components.
2. Check a starter key switch using an ohmmeter.
3. Find, test, and repair neutral safety devices.
4. Use a test light, voltmeter, and an ohmmeter to check a starter solenoid.
5. Bench test a starter motor.
6. Check starting system wires for opens and shorts using an ohmmeter.
7. Remove and replace outboard engine starter motors.
8. Remove and repair or replace starter motor drive assembly.

LEARNING ACTIVITIES:
1. Participate in class lectures and discussions. (Objectives 1 - 8)
2. Select a service manual for an outboard engine equipped with an electric starting system. Read the section about the operation of the starting system. Read the section about troubleshooting the starting system.
3. Observe a demonstration of troubleshooting a starter solenoid.
4. Practice troubleshooting starting systems on shop engines.

EVALUATION/CHECK-OUT:
You will be given opportunities to troubleshoot and repair the starting systems on outboard engine brought into the shop. Your ability to find trouble and make repairs will be evaluated. Your performance will be recorded on the Repairing Starting Systems performance checklist.

RESOURCES:

LEARNING MATERIALS:
1. Reference
   Manufacturer's service manuals.

EQUIPMENT:
1. Engines equipped with electric starters.
2. Student basic tool kit.
3. Voltmeter.
4. Ohmmeter.

AUDIO VISUAL MATERIALS:
(none used)

NAME________________________ STUDENT NO.________________________

14.02 **PERFORMANCE CHECKLIST**

MODULE : REPAIRING STARTING SYSTEMS

COMPETENCY: Troubleshoot and repair starter, starter solenoid, starter key switch, and neutral safety devices.

1. ☐ Recognized and named starting system components
2. ☐ Detected bad key switch using ohmmeter
3. ☐ Selected and installed replacement key switch
4. ☐ Found defective neutral safety devices with ohmmeter
5. ☐ Selected, installed, and adjusted neutral safety devices
6. ☐ Detected faulty starter solenoid with test light
7. ☐ Detected faulty starter solenoid with voltmeter
8. ☐ Detected faulty starter solenoid with ohmmeter
9. ☐ Selected and installed replacement starter solenoid
10. ☐ Checked starting system wires for opens and shorts
11. ☐ Removed and replace starter motor
12. ☐ Removed and replaced starter motor drive components
13. ☐
14. ☐
15. ☐

COMPETENCY ACHIEVED? ☐ YES ☐ NO

EXPLANATION:

MODULE 14.03

REPAIRING RECOIL STARTERS **INSTRUCTOR GUIDE**

COMPETENCY:
Troubleshoot and repair outboard motor recoil starters.

INSTRUCTIONAL OBJECTIVES:

The student will be able to:
1. Recognize and name recoil starter parts.
2. Renew recoil starter pull ropes.
3. Renew recoil starter clutch pawls.
4. Renew recoil starter rewind springs.
5. Time recoil starter with flywheel.

LEARNING ACTIVITIES:
1. Participate in class lectures and discussions.
   (Objectives 1 - 5)

2. Locate the manufacturer's service manual for an engine equipped with a recoil starter. Find and read the section about recoil starters and read about how to disassemble and repair them.
   (Objectives 1 - 5)

3. Practice disassembling/reassembling a recoil starter in the shop.
   (Objectives 1 - 5)

EVALUATION/CHECK-OUT:
1. The instructor will observe you as you practice your recoil starter techniques on the shop control boxes. Your ability to work on control box components will be recorded on the performance checklist.

2. You will be given opportunities to troubleshoot and repair recoil starters on engines which have been brought into the shop. Your ability to find trouble, analyze failures, and make the necessary repairs will be evaluated and recorded on the performance checklist.

RESOURCES:

LEARNING MATERIALS:
1. Reference
   Manufacturer's service manuals for engines with manual starters.

EQUIPMENT:
1. Engines equipped with recoil starters for students to practice taking apart.
2. Student tool kits.

(Refer to the Tools section of this document for specifications.)

3. Live work or bugged engines for students to practice troubleshooting and repair techniques. If live work will be used try to plan ahead and arrange for engines to be brought in.

AUDIO VISUAL MATERIALS:

(none used)

NAME______________________ **STUDENT NO.**______________________

14.03

PERFORMANCE CHECKLIST

MODULE : REPAIRING RECOIL STARTERS

COMPETENCY: Troubleshoot and repair recoil starters

1. ☐ Recognized and named recoil starter components
2. ☐ Removed recoil starter from engine
3. ☐ Disassembled and cleaned recoil starter
4. ☐ Selected pull rope and cut it to proper length
5. ☐ Whipped ends of pull rope
6. ☐ Installed pull rope
7. ☐ Installed rewind spring
8. ☐ Installed clutch pawls
9. ☐ Selected and applied lubricants as required
10. ☐ Pre-wound rewind spring
11. ☐ Timed recoil starter with flywheel as required
12. ☐ Installed pull handle
13. ☐ Installed recoil starter on engine
14. ☐
15. ☐

COMPETENCY ACHIEVED? ☐ **YES** ☐ **NO**

EXPLANATION:

UNIT 18 - OUTBOARD POWERHEAD

MODULE 15.01

REPAIRING THE OUTBOARD POWERHEAD **INSTRUCTOR GUIDE**

COMPETENCY:

1. Use basic motor inspection techniques to identify powerhead trouble.
2. Remove and reinstall powerhead.
3. Disassemble powerhead into its major components.
4. Disassemble, clean, inspect, reassemble crankshaft assembly.
5. Disassemble, clean, inspect, reassemble piston/rod assembly.
6. Disassemble, clean, inspect, repair cylinder block and crankcase.
7. Reassemble powerhead.

INSTRUCTIONAL OBJECTIVES:

The student will be able to:

1. Recognize and name powerhead components.
2. Explain the function and operation of powerhead components.
3. Determine the need for powerhead repairs through the use of the basic motor inspection.
4. Select and use powerhead special tools.
5. Remove powerhead and leave midsection on boat.
6. Remove powerhead electrical system as an assembly.
7. Remove fuel system as an assembly.
8. Disassemble powerhead into major components.
9. Analyze powerhead failures.
10. Disassemble, clean, inspect, and reassemble reed blocks.
11. Remove carbon deposits from cylinder block.
12. Hone cylinders.
13. Inspect crankcase and cylinder block.
14. Disassemble, clean, and inspect crankshaft assembly.
15. Disassemble, clean, and inspect piston/rod assembly.
16. Select and use sealing compounds during powerhead assembly.
17. Prepare cylinder block and crankcase for reassembly.
18. Reassemble piston/rod assembly and install in cylinder block.
19. Reassemble crankshaft assembly and install in cylinder block.
20. Install crankcase on cylinder block.
21. Install reed blocks and intake manifold.
22. Prepare and install a cylinder head and gasket.
23. Install fuel system assembly on powerhead.
24. Install electrical system assembly on powerhead.
25. Install assembled powerhead on midsection.
26. Determine powerhead break-in procedures.

LEARNING ACTIVITIES:

1. Participate in class lectures and discussions. (Objectives 1 - 26)

2. Locate a manufacturer' service manual for a low horsepower, midrange horsepower, and a high horsepower engine. Read about powerhead removal, disassembly, cleaning, inspection, and reassembly in each. Be sure to find and read the sections on break-in procedures.
   (Objectives 1 - 26)

3. Observe the following demonstrations:
   - Powerhead Removal and Installation.
   - Powerhead Disassembly
   - Inspecting Pistons, Rods, and Cylinders
   - Inspecting Crankshafts

   (Objectives 1 - 10, 13 - 25)

4. Practice powerhead removal, disassembly/reassembly, and inspection techniques on engines in the shop. Familiarize yourself with the use of any recommended special tools.
   (Objectives 1 - 25)

EVALUATION/CHECK-OUT:

1. The instructor will observe you as you practice your powerhead techniques on the shop engines. Your ability to work on powerhead components will be recorded on the performance checklist.

2. You will be given opportunities to troubleshoot and repair powerheads on engines which have been brought into the shop. Your ability to find trouble, analyze failures, and make the necessary repairs will be evaluated and recorded on the performance checklist.

RESOURCES:

LEARNING MATERIALS:

1. Reference
   Manufacturer's service manuals.

EQUIPMENT:

1. Engines for demonstrating powerhead removal and disassembly and reassembly.
2. Engine crane.
3. Powerhead special tools as required.
   (Refer to the Tools section of this document for specifications.)
4. Student tool kits.
   (Refer to the Tools section of this document for specifications.)
5. Live work or bugged engines for students to practice troubleshooting and repair techniques. If live work will be used try to plan ahead and arrange for engines to be brought in.

AUDIO VISUAL MATERIALS:

(none used)

NAME____________________________ **STUDENT NO.**____________________________

15.01 **PERFORMANCE CHECKLIST** 1 of 1

MODULE : **REPAIRING THE OUTBOARD POWERHEAD**

COMPETENCY: Use basic motor inspection techniques to identify powerhead trouble.

1. ☐ Performed spark check
2. ☐ Performed gearcase check
3. ☐ Performed compression check
4. ☐ Detected compression problems
5. ☐ Removed cylinder head
6. ☐ Inspected cylinder head, gasket, and cylinder
7. ☐ Detected faulty head, gasket, cylinder
8. ☐ Inspected piston dome
9. ☐ Detected detonation damage
10. ☐ Removed intake bypass to check piston rings and skirt
11. ☐ Detected stuck rings
12. ☐ Detected piston scuffing
13. ☐ Performed rod endplay check
14. ☐ Detected rod endplay
15. ☐ Recommended appropriate service procedures based on motor inspection

COMPETENCY ACHIEVED? ☐ **YES** ☐ **NO**

EXPLANATION:

NAME________________________ STUDENT NO.________________________

15.01 **PERFORMANCE CHECKLIST** 1 of 1

MODULE : REPAIRING THE OUTBOARD POWERHEAD

COMPETENCY: Remove and reinstall powerhead.

1. ☐ Selected and set up engine crane
2. ☐ Selected and installed powerhead lift ring
3. ☐ Disconnected fuel system
4. ☐ Disconnected electrical system
5. ☐ Disconnected bonding/grounding straps
6. ☐ Disconnected shift linkage
7. ☐ Removed mounting screws/nuts
8. ☐ Lifted powerhead off midsection
9. ☐ Packaged and labeled loose hardware
10. ☐ Cleaned and prepared powerhead mounting surfaces
11. ☐ Sealed and installed powerhead base gasket
12. ☐ Hoisted powerhead onto midsection
13. ☐ Installed attaching hardware
14. ☐ Reconnected fuel and electrical systems
15. ☐ Tested engine in tank

COMPETENCY ACHIEVED? ☐ YES ☐ NO

EXPLANATION:

NAME____________________________ **STUDENT NO.**____________________________

15.01 **PERFORMANCE CHECKLIST** 1 of 2

MODULE : REPAIRING THE OUTBOARD POWERHEAD

COMPETENCY: Disassemble powerhead into its major components

1. ☐ Recognized and named powerhead components
2. ☐ Explained the function of powerhead components
3. ☐ Prepared work area for powerhead disassembly
4. ☐ Selected puller and removed flywheel
5. ☐ Removed wiring harness and electrical components
6. ☐ Removed carburetors as an assembly
7. ☐ Removed fuel pump, oil pump, and primer system
8. ☐ Removed throttle/timing linkage components
9. ☐ Removed cylinder heads
10. ☐ Removed exhaust water jacket covers/baffles
11. ☐ Removed intake bypass covers
12. ☐ Removed intake manifold
13. ☐ Removed crankcase
14. ☐ Removed pistons
15. ☐ Put rod caps back on rods after piston removal

COMPETENCY ACHIEVED? ☐ **YES** ☐ **NO**

EXPLANATION:

NAME______________________________ **STUDENT NO.**______________________________

15.01	**PERFORMANCE CHECKLIST** contd.	2 of 2

MODULE : **REPAIRING THE OUTBOARD POWERHEAD**

COMPETENCY: Disassemble powerhead into its major components

16. ☐ Labeled piston and rod with cylinder number
17. ☐ Packaged and labeled rod bearings
18. ☐ Removed crankshaft from cylinder block
19. ☐ Organized components for inspection and cleaning.
20. ☐
21. ☐
22. ☐
23. ☐
24. ☐
25. ☐
26. ☐
27. ☐
28. ☐
29. ☐
30. ☐

COMPETENCY ACHIEVED? ☐ **YES** ☐ **NO**

EXPLANATION:

NAME____________________________ **STUDENT NO.**____________________________

15.01 **PERFORMANCE CHECKLIST** 1 of 2

MODULE : **REPAIRING THE OUTBOARD POWERHEAD**

COMPETENCY: Disassemble, clean, inspect, repair, and reassemble crankshaft

1. ☐ Removed crankshaft endcaps
2. ☐ Removed and replaced endcap seals
3. ☐ Removed endcap crankshaft seals
4. ☐ Installed endcap crankshaft seals in required direction
5. ☐ Inspected top and bottom crankshaft main bearings
6. ☐ Detected faulty top and bottom main bearings.
7. ☐ Selected puller and removed end mains from crankshaft
8. ☐ Removed and inspected center main crankshaft bearings
9. ☐ Packaged and labeled center main bearing parts
10. ☐ Detected faulty center main bearings
11. ☐ Inspected all crankshaft bearing surfaces.
12. ☐ Detected water marks/pitting on crank bearing surfaces
13. ☐ Measured all crank bearing surfaces
14. ☐ Detected rod and main bearing surface wear
15. ☐ Checked crankshaft for straightness

COMPETENCY ACHIEVED? ☐ **YES** ☐ **NO**

EXPLANATION:

NAME____________________________ **STUDENT NO.**____________________________

15.01 **PERFORMANCE CHECKLIST** contd. 2 of 2

MODULE : **REPAIRING THE OUTBOARD POWERHEAD**

COMPETENCY: Disassemble, clean, inspect, repair, and reassemble crankshaft

16. ☐ Detected bent crankshaft
17. ☐ Inspected crankshaft sealing surfaces
18. ☐ Detected faulty crank sealing surfaces
19. ☐ Selected and installed Speedy Sleeve
20. ☐ Cleaned crankshaft and components for assembly
21. ☐ Organized crankshaft and components for assembly
22. ☐ Selected tools and pressed end mains onto crank
23. ☐ Selected assembly lubricant for center main bearings
24. ☐ Used assembly lube and installed center main bearings
25. ☐
26. ☐
27. ☐
28. ☐
29. ☐
30. ☐

COMPETENCY ACHIEVED? ☐ **YES** ☐ **NO**

EXPLANATION:

NAME________________________ STUDENT NO.______________________

15.01 **PERFORMANCE CHECKLIST** 1 of 2

MODULE : REPAIRING THE OUTBOARD POWERHEAD

COMPETENCY: Disassemble, clean, inspect, repair, and reassemble piston/rod assembly.

1. ☐ Checked service manual for piston removal procedure
2. ☐ Used ring expander to remove piston rings
3. ☐ Selected piston disassembly tools
4. ☐ Removed piston pin from piston
5. ☐ Captured, packaged, and labeled piston pin bearings
6. ☐ Inspected piston pin
7. ☐ Detected water marks, pitting, chatter in piston pin
8. ☐ Measured piston pin
9. ☐ Detected piston pin wear
10. ☐ Decarbonized piston
11. ☐ Checked service manual for piston measuring procedure
12. ☐ Measured pistons
13. ☐ Detected worn or out-of-spec pistons
14. ☐ Inspected pistons for scuffing and cracks
15. ☐ Measured ring grooves

COMPETENCY ACHIEVED? ☐ YES ☐ NO

EXPLANATION:

NAME______________________ **STUDENT NO.**______________________

15.01 **PERFORMANCE CHECKLIST** contd. 2 of 2

MODULE : REPAIRING THE OUTBOARD POWERHEAD

COMPETENCY: Disassemble, clean, inspect, repair, and reassemble piston/rod assembly.

16. ☐ Inspected rod bearing surfaces
17. ☐ Detected water marks and pits on rods
18. ☐ Used surface plate and feeler gauge to check rod warp
19. ☐ Detected rod warp
20. ☐ Constructed rod crosshatching tool
21. ☐ Crosshatched rods
22. ☐ Cleaned and organized parts for assembly
23. ☐ Checked service manual for piston assembly procedure
24. ☐ Selected piston assembly tools
25. ☐ Selected piston assembly lube
26. ☐ Assembled piston and rod per manufacturer's procedure
27. ☐ Checked ring end gap for each cylinder
28. ☐ Used ring expander to install piston rings
29. ☐ Organized pistons for assembly into cylinder block
30. ☐

COMPETENCY ACHIEVED? ☐ **YES** ☐ **NO**

EXPLANATION:

NAME_____________________________ **STUDENT NO.**____________________________

15.01 **PERFORMANCE CHECKLIST** 1 of 1

MODULE : REPAIRING THE OUTBOARD POWERHEAD

COMPETENCY: Disassemble, clean, inspect, and repair crankcase and cylinder block

1. ☐ Disassembled cylinder heads
2. ☐ Inspected and cleaned head water jacket area
3. ☐ Tested thermostats
4. ☐ Decarbonized cylinder block and exhaust baffles
5. ☐ Inspected cylinders for pits, scuffing, cracking
6. ☐ Honed and crosshatched cylinders
7. ☐ Measured cylinders.
8. ☐ Detected deformed and out-of-spec cylinders
9. ☐ Inspected and cleaned cylinder block water jacket
10. ☐ Reassembled and surfaced cylinder head
11. ☐ Inspected fuel bleed system fittings, orifices
12. ☐ Cleaned and prepared cylinder block and crankcase for powerhead reassembly
13. ☐
14. ☐
15. ☐

COMPETENCY ACHIEVED? ☐ **YES** ☐ **NO**

EXPLANATION:

NAME__________________________ **STUDENT NO.**__________________________

15.01 **PERFORMANCE CHECKLIST** 1 of 2

MODULE : REPAIRING THE OUTBOARD POWERHEAD

COMPETENCY: Reassemble powerhead

1. ☐ Organized powerhead components for assembly
2. ☐ Obtained required special tools
3. ☐ Pre-sealed gaskets as required
4. ☐ Checked that crankshaft was correctly assembled
5. ☐ Checked that pistons were correctly assembled
6. ☐ Checked that crank endcaps were correctly assembled
7. ☐ Mounted crank with correct orientation in cylinder block
8. ☐ Checked for alignment of bearing races and dowel pins
9. ☐ Secured crank to block by installing endcap screws
10. ☐ Lubricated cylinders and pistons
11. ☐ Installed ring compressor on piston
12. ☐ Installed piston into cylinder block
13. ☐ Used assembly lube and installed rod bearing.
14. ☐ Installed and aligned rod cap
15. ☐ Checked orientation of piston in cylinder

COMPETENCY ACHIEVED? ☐ **YES** ☐ **NO**

EXPLANATION:

NAME______________________________ **STUDENT NO.**______________________________

15.01 **PERFORMANCE CHECKLIST** contd. 2 of 2

MODULE : REPAIRING THE OUTBOARD POWERHEAD

COMPETENCY: Reassemble powerhead

16. ☐ Used three part sequence to torque rod screws
17. ☐ Checked piston rings for dowel pin snag after installed
18. ☐ Checked crank rotation for binding
19. ☐ Applied crankcase-to-block sealer
20. ☐ Mounted crankcase on cylinder block
21. ☐ Tapped alignment dowel pins into position
22. ☐ Torqued crankcase fasteners to specification
23. ☐ Torqued endcap fasteners
24. ☐ Installed exhaust and water jacket covers
25. ☐ Installed intake bypass covers
26. ☐ Installed cylinder heads and gaskets
27. ☐ Used multi-part sequence to torque head bolts to spec
28. ☐ Installed fuel bleed system hoses
29. ☐ Installed electrical system
30. ☐ Installed fuel system

COMPETENCY ACHIEVED? ☐ **YES** ☐ **NO**

EXPLANATION:

MODULE 15.02

REPAIRING OUTBOARD COOLING SYSTEM **INSTRUCTOR GUIDE**

COMPETENCY:
Troubleshoot and repair outboard engine cooling system.

INSTRUCTIONAL OBJECTIVES:

The student will be able to:
1. Recognize and name cooling system components.
2. Explain how outboard motor cooling system operates.
3. Describe boat operating situations which can cause outboard engines to overheat.
4. Name the causes of water pump impeller failure.
5. Describe the effect of overheating on powerhead components.
6. Explain the effect of exhaust gas entering cooling system water passages.
7. Use a digital thermometer and Thermo-melt sticks to measure engine temperature.
8. Remove and test thermostat.
9. Measure cooling system water pressure.
10. Remove, rebuild, and reinstall water pump
11. Explain how outboard engine overheat warning system operates.
12. Troubleshoot and repair overheat warning system

LEARNING ACTIVITIES:
1. Participate in class lectures and discussions.
   (Objectives 1 - 12)
2. Observe the following demonstrations:
   Water Pump Impeller Installation
   Troubleshooting Overheat Warning Systems
   (Objectives 2 - 4, 10 - 12)
3. Select a manufacturer's service manual for a low, a medium, and a high horsepower engine. Locate the Cooling System section in each. Read about cooling system operation, troubleshooting, and repair.

4. Practice your cooling system troubleshooting and repair skills on engines in the shop.

EVALUATION/CHECK-OUT:
You will be given opportunities to troubleshoot and repair cooling systems in the shop. The instructor will evaluate your ability to locate faulty components and make the necessary repairs. Your performance will be recorded on the Troubleshooting and Repairing Cooling Systems performance checklist.

RESOURCES:

MODULE 15.02

LEARNING MATERIALS:

1. Reference
   Manufacturer's service manuals.

EQUIPMENT:

1. Engines for demonstrating water pump removal, impeller installation, and overheat warning system troubleshooting techniques.
2. Water pressure gauge.
   (Refer to the Tools section of this document for specifications.)
3. Test light and VOM.
   (Refer to the Tools section of this document for specifications.)
4. Student tool kits.
   (Refer to the Tools section of this document for specifications.)
5. Live work or bugged engines for students to practice troubleshooting and repair techniques. If live work will be used try to plan ahead and arrange for engines to be brought in.

AUDIO VISUAL MATERIALS:

(none used)

NAME____________________________ **STUDENT NO.**____________________________

15.02 **PERFORMANCE CHECKLIST** 1 of 2

MODULE : REPAIRING OUTBOARD ENGINE COOLING SYSTEM

COMPETENCY: Troubleshoot and repair outboard engine cooling system

1. ☐ Named cooling system components
2. ☐ Described cooling system operation
3. ☐ Described causes of engine overheating
4. ☐ Stated reasons for water pump impeller failure
5. ☐ Measured engine temperature with Thermo-melt sticks
6. ☐ Removed thermostat and tested it using hot water method
7. ☐ Measured cooling system water pressure
8. ☐ Removed gearcase to access water pump
9. ☐ Removed water pump housing and impeller
10. ☐ Installed impeller with correct vane orientation
11. ☐ Selected and applied sealers as required
12. ☐ Reinstalled gearcase
13. ☐ Checked shift operation
14. ☐ Started and ran engine to check water pump installation
15. ☐ Checked service manual for overheat warning system test procedures

COMPETENCY ACHIEVED? ☐ YES ☐ NO

EXPLANATION:

NAME______________________ **STUDENT NO.**______________________

15.02 **PERFORMANCE CHECKLIST contd.** 2 of 2

MODULE : **REPAIRING OUTBOARD ENGINE COOLING SYSTEM**

COMPETENCY: Troubleshoot and repair outboard engine cooling system

16. ☐ Tested overheat sensor
17. ☐ Tested overheat warning horn
18. ☐ Checked engine control section of overheat protection system
19. ☐
20. ☐
21. ☐
22. ☐
23. ☐
24. ☐
25. ☐
26. ☐
27. ☐
28. ☐
29. ☐
30. ☐

COMPETENCY ACHIEVED? ☐ **YES** ☐ **NO**

EXPLANATION:

UNIT 26 - OUTBOARD
MID-SECTION

MODULE 16.01

REPAIRING OUTBOARD MIDSECTION COMPONENTS INSTRUCTOR GUIDE

COMPETENCY:

1. Troubleshoot and repair stern bracket.
2. Troubleshoot and repair swivel bracket.
3. Troubleshoot and repair drive shaft housing.
4. Troubleshoot and repair motor mounts.

INSTRUCTIONAL OBJECTIVES:

The student will be able to:

1. Recognize and name midsection components.
2. Check, remove and reinstall tilt tubes.
3. Check, remove and reinstall motor mounts.
4. Remove and reinstall drive shaft housing.
5. Check drive shaft housing for parallelism.
6. Remove and reinstall exhaust diffusers and megaphones.
7. Check, remove and reinstall drive shaft housing water tubes.
8. Remove and reinstall transom bracket assembly.
9. Remove and reinstall swivel bracket assembly.
10. Check, remove and reinstall swivel bracket bushings.
11. Remove and reinstall steering arm assembly.
12. Lubricate swivel bracket and tilt tube components.

LEARNING ACTIVITIES:

1. Participate in class lectures and discussions.
   (Objectives 1 - 12)
2. Locate the service manual for a low horsepower, mid-range horsepower, and a large horsepower engine. Go to the Engine Midsection part of each manual and read about motor mounts, swivel brackets, transom brackets, and drive shaft housings. Familiarize yourself with the repair procedures for each.
   (Objectives 1 - 12)
3. Observe the following demonstrations:
   Tilt Tube Removal
   Removing and Measuring The Drive Shaft Housing
   Removing The Swivel Bracket Assembly
   (Objectives 1 - 3, 4, 8)
4. Practice outboard midsection removal and installation techniques on engines in the shop.
   (Objectives 1 -12)

EVALUATION/CHECK-OUT:

You will be given opportunities to work on the midsection assemblies of engines which are brought into the shop. The instructor will evaluate your ability to remove, repair, and replace midsection components. Your performance will be recorded on the Repairing Outboard Midsection

MODULE 16.01

Components performance checklist.

RESOURCES:

LEARNING MATERIALS:

1. Reference
   Copies of manufacturer's engine service manuals.

EQUIPMENT:

1. Engines for demonstrating midsection component removal techniques.
2. Student tool kits.
   (Refer to the Tools section of this document for specifications.)
3. Surface plate and 36 inch machinist's scale
   (Refer to the Tools section of this document for specifications.)
4. Live work or bugged engines for students to practice troubleshooting and repair techniques. If live work will be used try to plan ahead and arrange for engines to be brought in.

AUDIO VISUAL MATERIALS:

(none used)

NAME____________________________ **STUDENT NO.**____________________________

16.01

PERFORMANCE CHECKLIST

MODULE : REPAIRING OUTBOARD MIDSECTION COMPONENTS

COMPETENCY: Troubleshoot and repair stern bracket

1. ☐ Identified stern bracket and components
2. ☐ Checked stern brackets and tilt tube for defects
3. ☐ Pulled powerhead and gearcase
4. ☐ Removed stern bracket
5. ☐ Installed transom clamps
6. ☐ Reinstalled powerhead and gearcase
7. ☐ Use tilt tube puller to remove tilt tube
8. ☐ Installed tilt tube
9. ☐
10. ☐
11. ☐
12. ☐
13. ☐
14. ☐
15. ☐

COMPETENCY ACHIEVED? ☐ **YES** ☐ **NO**

EXPLANATION:

NAME________________________ STUDENT NO.________________________

16.01

PERFORMANCE CHECKLIST

MODULE : REPAIRING OUTBOARD MIDSECTION COMPONENTS

COMPETENCY: Troubleshoot and repair swivel bracket

1. ☐ Identified swivel bracket and components
2. ☐ Checked swivel bracket castings for defects
3. ☐ Pulled powerhead and gearcase
4. ☐ Removed stern bracket
5. ☐ Removed swivel bracket from driveshaft housing
6. ☐ Checked swivel bushings
7. ☐ Checked steering arm
8. ☐ Installed swivel bushings
9. ☐ Installed steering arm
10. ☐ Reinstalled swivel bracket on driveshaft housing
11. ☐ Reinstalled stern bracket
12. ☐ Mount midsection on boat
13. ☐ Reinstall powerhead and gearcase
14. ☐
15. ☐

COMPETENCY ACHIEVED? ☐ YES ☐ NO

EXPLANATION:

NAME______________________ **STUDENT NO.**______________________

16.01	**PERFORMANCE CHECKLIST**

MODULE : REPAIRING OUTBOARD MIDSECTION COMPONENTS

COMPETENCY: Troubleshoot and repair driveshaft housing

1. ☐ Identified drive shaft housing and components
2. ☐ Removed drive shaft housing assembly from engine
3. ☐ Measured drive shaft housing for parallelism
4. ☐ Inspected water passages
5. ☐ Removed and replaced exhaust diffusers
6. ☐ Reinstalled driveshaft housing
7. ☐ Installed midsection assembly on boat
8. ☐ Reinstalled powerhead and gearcase
9. ☐ Installed steering arm
10. ☐ Reinstalled swivel bracket on driveshaft housing
11. ☐ Reinstalled stern bracket
12. ☐ Mount midsection on boat
13. ☐ Reinstall powerhead and gearcase
14. ☐
15. ☐

COMPETENCY ACHIEVED? ☐ **YES** ☐ **NO**

EXPLANATION:

NAME____________________________ **STUDENT NO.**____________________________

16.01

PERFORMANCE CHECKLIST

MODULE : REPAIRING OUTBOARD MIDSECTION COMPONENTS

COMPETENCY: Troubleshoot and repair motor mounts

1. ☐ Identified motor mounts and components
2. ☐ Checked motor mounts for defects
3. ☐ Removed power head and gearcase as necessary
4. ☐ Removed driveshaft housing as necessary
5. ☐ Replaced motor mount components
6. ☐ Reinstalled driveshaft housing
7. ☐ Installed midsection assembly on boat
8. ☐ Reinstalled powerhead and gearcase
9. ☐
10. ☐
11. ☐
12. ☐
13. ☐
14. ☐
15. ☐

COMPETENCY ACHIEVED? ☐ **YES** ☐ **NO**

EXPLANATION:

MODULE 16.02

REPAIRING TRIM AND TILT SYSTEMS **INSTRUCTOR GUIDE**

COMPETENCY:
Troubleshoot and repair power trim/tilt system.

INSTRUCTIONAL OBJECTIVES:

The student will be able to:
1. Recognize and name trim/tilt system hydraulic components.
2. Recognize and name trim/tilt system electrical components.
3. Explain how power trim and tilt systems work.
4. Use manual release valves to lower tilted engines.
5. Check hydraulic fluid level in power trim/tilt unit.
6. Add hydraulic fluid to trim/tilt reservoir.
7. Use pressure gauge to find defects in power trim/tilt hydraulic components.
8. Use test light, voltmeter, and ohmmeter to locate defects in power trim/tilt control switches.
9. Use test light, voltmeter, and ohmmeter to locate defects in power trim/tilt solenoids.
10. Use test light, voltmeter, and ohmmeter to detect and isolate defective trim/tilt hydraulic pump motor.
11. Remove and reinstall power trim/tilt hydraulic assembly.
12. Replace trim/tilt unit check valves.
13. Reseal trim and tilt rams
14. Remove and replace power trim/tilt control switches.
15. Remove and replace power trim/tilt solenoids.
16. Remove and replace power trim/tilt motor.
17. Repair tilt lock assembly.
18. Repair reverse lock assembly.
19. Use ohmmeter to troubleshoot trim position indicator assembly.
20. Calibrate and adjust trim position indicator.

LEARNING ACTIVITIES:
1. Participate in class lectures and discussions.
(Objectives 1 - 20)
2. Locate a service manual for an outboard engine which is equipped with power trim and tilt. Go to the Power Trim and Tilt System part of the manual and read about power trim/tilt system components and their troubleshooting procedures. Familiarize yourself with the repair procedures for each component.
(Objectives 1 - 20)
3. Observe the following demonstrations:
   Using the Trim/Tilt Manual Release Valve
   Using the Power Trim/Tilt Pressure Tester
   Removing the Power Trim/Tilt Assembly
   Disassembling the Power Trim/Tilt Unit

MODULE 16.02

Calibrating the Trim Position Indicator
Troubleshooting Trim/Tilt System Electrical Components
(Objectives 1 - 20)

4. Practice power trim/tilt unit removal, installation, and electrical troubleshooting techniques on engines in the shop.
(Objectives 1 - 20)

EVALUATION/CHECK-OUT:
You will be given opportunities to work on the power trim/tilt systems of engines which are brought into the shop. The instructor will evaluate your ability to troubleshoot, remove, repair, and replace power trim/tilt system components. Your performance will be recorded on the Repairing Trim/Tilt System Components performance checklist.

RESOURCES:

LEARNING MATERIALS:

1. Reference
Copies of manufacturer's engine service manuals.

EQUIPMENT:

1. Engines for demonstrating power trim tilt system troubleshooting, removal, disassembly, and repair techniques.
2. Student tool kits.
(Refer to the Tools section of this document for specifications.)
3. Power Trim/Tilt pressure tester
(Refer to the Tools section of this document for specifications.)
4. Live work or bugged engines for students to practice troubleshooting and repair techniques. If live work will be used try to plan ahead and arrange for engines to be brought in.

AUDIO VISUAL MATERIALS:
(none used)

435

NAME____________________________ **STUDENT NO.**____________________________

16.02 **PERFORMANCE CHECKLIST** 1 of 2

MODULE : **REPAIRING TRIM AND TILT SYSTEMS**

COMPETENCY: Troubleshoot and repair power trim and tilt system.

1. ☐ Recognized and named trim/tilt system components
2. ☐ Explained operation of power trim/tilt system
3. ☐ Checked hydraulic fluid level
4. ☐ Selected and added hydraulic fluid to reservoir
5. ☐ Operated manual release valve to lower engine
6. ☐ Detected faulty trim/tilt control switches
7. ☐ Removed and replaced trim/tilt control switches
8. ☐ Detected faulty trim/tilt solenoids
9. ☐ Removed and replaced trim/tilt solenoids
10. ☐ Detected faulty trim/tilt hydraulic pump motor
11. ☐ Removed and replaced hydraulic pump motor
12. ☐ Detected check valve trouble using pressure tester
13. ☐ Removed trim/tilt assembly from engine
14. ☐ Disassembled trim/tilt unit
15. ☐ Replaced check valves

COMPETENCY ACHIEVED? ☐ **YES** ☐ **NO**

EXPLANATION:

NAME____________________________ **STUDENT NO.**____________________________

16.02 **PERFORMANCE CHECKLIST** contd. 2 of 2

MODULE : REPAIRING TRIM AND TILT SYSTEMS

COMPETENCY: Troubleshoot and repair power trim and tilt system.

16. ☐ Assembled power trim/tilt unit
17. ☐ Installed power trim/tilt unit on engine
18. ☐ Purged air from hydraulic system
19. ☐ Repaired or replaced lock assembly
20. ☐ Repaired or replaced reverse lock assembly
21. ☐ Detected faulty trim/tilt position indicator components
22. ☐ Removed and replaced position indicator components
23. ☐ Calibrated trim position indicator

☐
☐
☐
☐
☐
☐
☐

COMPETENCY ACHIEVED? ☐ **YES** ☐ **NO**

EXPLANATION:

UNIT 17 – GEAR CASES

MODULE 17.01

REPAIRING OUTBOARD GEARCASES **INSTRUCTOR GUIDE**

COMPETENCY:
Troubleshoot and repair outboard engine gearcases.

INSTRUCTIONAL OBJECTIVES:

The Student will be able to:
1. Remove and install gearcases.
2. Recognize and name the component parts of a gearcase assembly.
3. State the three driveshaft lengths available on United States manufactured outboard engines.
4. Explain the operation of shifting gearcases.
5. Examine gearcase lubricant for evidence of trouble.
6. Pressure test gearcases.
7. Select and change gear lubricant.
8. Remove propellers.
9. Perform a gearcase seal job.
10. Disassemble and clean gearcase and components.
11. Inspect gears, bearings, and shift mechanism components.
12. Check for bent driveshafts.
13. Check for bent propshafts.
14. Shim driveshaft for pinion gear height.
15. Shim forward gear to backlash specifications.
16. Shim reverse gear for backlash specifications.
17. Assemble gearcase components and gearcase.
18. Adjust shift shaft height.
19. Remove and replace zincs.

LEARNING ACTIVITIES:
1. Participate in class lectures and discussions.
   (Objectives 1 - 19)

2. Select a manufacturer's service manual for an engine which has a forward-neutral-reverse shifting gearcase. Find the gearcase section of the manual and read about gearcase operation, troubleshooting, and repair.
   (Objectives 1 - 19)

3. Go to one of the gearcase cutaways in the shop. Use the cutaway to observe the operation of the gearcase shifting mechanism while turning the driveshaft.
   (Objective 4)

4. View the following videotapes:
   "Introduction To The Counter-rotating V6 Outboard Gearcases"

MODULE 17.01

"Using the P/N 393185 Shim Gauge"

5. Observe the following demonstrations:
   Pressure Checking Gearcases
   Shimming For Pinion Gear Height
   Shimming For Forward and Reverse Gear Backlash
   (Objectives 10 - 17)

6. Practice gearcase removal, disassembly/reassembly, and inspection techniques on engines in the shop. Familiarize yourself with the use of any recommended special tools.
   (Objectives 1 - 19)

EVALUATION/CHECK-OUT:

1. The instructor will observe you as you practice your gearcase techniques on the shop engines. Your ability to work on gearcase components will be recorded on the performance checklist.

2. You will be given opportunities to troubleshoot and repair gearcases on engines which have been brought into the shop. Your ability to find trouble, analyze failures, and make the necessary repairs will be evaluated and recorded on the performance checklist.

RESOURCES:

LEARNING MATERIALS:

1. Reference
   Manufacturer's service manuals

EQUIPMENT:

1. Gearcases for demonstrating pressure checking and shimming procedures.
2. Shop engines for students to practice gearcase removal and disassembly procedures.
3. Gearcase special tools as required.
   (Refer to the Tools section of this document for specifications.)
4. Student tool kits.
   (Refer to the Tools section of this document for specifications.)
5. Live work or bugged engines for students to practice troubleshooting and repair techniques. If live work will be used try to plan ahead and arrange for engines to be brought in.

AUDIO VISUAL MATERIALS:

1. Videotape
   "Introduction to the Counter-rotating V6 Outboard Gearcases"
   OMC Training Department
   3145 Central Avenue - Desk C-613
   Waukegan, IL 60085

(312) 689-5531
P/N 79173

2. Videotape
"Using The P/N 393185 Shim Gauge"
OMC Training Department
3145 Central Avenue - Desk C-613
Waukegan, IL 60085
(312) 689-5531
P/N VT8330BSD

NAME______________________________ STUDENT NO.______________________________

17.01 **PERFORMANCE CHECKLIST** 1 of 3

MODULE : REPAIRING OUTBOARD GEARCASES

COMPETENCY: Troubleshoot and repair outboard engine gearcases.

1. ☐ Recognized and named gearcase components
2. ☐ Identified standard, long, extra long driveshafts
3. ☐ Explained operation of shifting gearcases
4. ☐ Selected gear lube and performed gearcase lube change
5. ☐ Identified gearcase trouble by "reading" gear lube
6. ☐ Removed propeller
7. ☐ Performed gearcase pressure test
8. ☐ Found defective seals using gearcase pressure test
9. ☐ Disconnected shift linkages and pitot tubes
10. ☐ Removed gearcase from engine midsection
11. ☐ Selected adapter and mounted gearcase in engine stand
12. ☐ Selected appropriate tool and removed bearing carrier
13. ☐ Disengaged pinion nut positive locking device
14. ☐ Selected appropriate tool and removed pinion nut/gear
15. ☐ Removed shift shaft as necessary

COMPETENCY ACHIEVED? ☐ YES ☐ NO

EXPLANATION:

NAME______________________________ **STUDENT NO.**______________________________

17.01 **PERFORMANCE CHECKLIST** contd. 2 of 3

MODULE : **REPAIRING OUTBOARD GEARCASES**

COMPETENCY: Troubleshoot and repair outboard engine gearcases.

16. ☐ Removed driveshaft and forward gear
17. ☐ Removed shift mechanism as necessary
18. ☐ Removed formard bearing race
19. ☐ Inspected gears, bearings, seals
20. ☐ Detected faulty gears, bearings, seals
21. ☐ Removed seals from bearing carrier
22. ☐ Selected tools and removed bearings from bearing carrier and gearcase driveshaft housing
23. ☐ Cleaned gearcase parts for assembly
24. ☐ Selected tools and shimmed for pinion gear height
25. ☐ Selected tools and shimmed for forward gear backlash
26. ☐ Selected tools and shimmed for reverse gear backlash
27. ☐ Checked driveshaft for bends, surface defects
28. ☐ Detected faulty driveshaft
29. ☐ Checked propshaft for bends, surface defects
30. ☐ Detected faulty driveshaft

COMPETENCY ACHIEVED? ☐ **YES** ☐ **NO**

EXPLANATION:

NAME______________________________ **STUDENT NO.**______________________________

17.01 **PERFORMANCE CHECKLIST** contd. 3 of 3

MODULE : REPAIRING OUTBOARD GEARCASES

COMPETENCY: Troubleshoot and repair outboard engine gearcases.

31. ☐ Installed driveshaft seals
32. ☐ Installed propshaft seals
33. ☐ Installed shift shaft seals
34. ☐ Selected and applied sealing compound on seals
35. ☐ Replaced fill and drain screw seals
36. ☐ Assembled bearing carrier
37. ☐ Assembled propshaft
38. ☐ Selected tools and installed driveshaft bearings
39. ☐ Installed driveshaft and pinion gear/nut
40. ☐ Torqued pinion nut to specification
41. ☐ Installed and seated bearing carrier then torqued nuts
42. ☐ Installed gearcase on engine midsection
43. ☐
44. ☐
45. ☐

COMPETENCY ACHIEVED? ☐ **YES** ☐ **NO**

EXPLANATION:

444

UNIT 18 - OUTBOARD CONTROLS

MODULE 18.01

REPAIRING STEERING SYSTEM & REMOTE CONTROLS INSTRUCTOR GUIDE

COMPETENCY:

1. Troubleshoot and repair mechanical steering system components.
2. Troubleshoot and repair control boxes and control cables.

INSTRUCTIONAL OBJECTIVES:

The student will be able to:

1. Recognize and name the following types of outboard steering sytems:
   - tiller
   - cable & pulley
   - hydraulic
   - rack & pinion cable
   - Safe-T style cable
2. Recognize and name steering system components.
3. Select steering cables by measuring boat.
4. Remove and replace steering cables.
5. Remove and replace helms.
6. Select control cables by measuring boat.
7. Remove, replace, and adjust control cables.
8. Recognize and name control box components.
9. Disassemble, inspect, and repair throttle and shift actuator mechanisms in control boxes.

LEARNING ACTIVITIES:

1. Participate in class lectures and discussions. (Objectives 1 - 9)
2. Locate a manufacturer's service manual for an engine which comes equipped with remote controls. Find and read the section on control cables and the control box. (Objectives 6 - 9)
3. Practice disassembling and reassembling the control boxes found in the shop. (Objectives 8 - 9)
4. Observe a demonstration of control cable installation and adjustment. (Objective 7)
5. Practice measuring boats in the shop for steering cables and control cables. (Objectives 3 - 5)

EVALUATION/CHECK-OUT:

1. The instructor will observe you as you practice your control box techniques on the shop control boxes. Your ability to work on control box components will be recorded on the performance checklist.

MODULE 18.01

2. You will be given opportunities to troubleshoot and repair control boxes, control cables, and steering systems on boats which have been brought into the shop. Your ability to find trouble, analyze failures, and make the necessary repairs will be evaluated and recorded on the performance checklist.

RESOURCES:

LEARNING MATERIALS:

1. Reference
   Manufacturer's service manuals

EQUIPMENT:

1. Boats for practicing steering and control cable measuring techniques and control cable adjusting techniques.
2. Control boxes for students to practice taking apart.
3. Examples of steering cables and control cables.
4. Student tool kits.
   (Refer to the Tools section of this document for specifications.)
5. Live work or bugged engines for students to practice troubleshooting and repair techniques. If live work will be used try to plan ahead and arrange for engines to be brought in.

AUDIO VISUAL MATERIALS:

(none used)

NAME______________________________ **STUDENT NO.**____________________________

18.01

PERFORMANCE CHECKLIST

MODULE : REPAIRING STEERING SYSTEM AND REMOTE CONTROLS

COMPETENCY: Troubleshoot and repair mechanical steering system and components.

1. ☐ Recognized and named types of steering systems
2. ☐ Recognized and named steering system components
3. ☐ Measured boat for steering cable
4. ☐ Removed engine as necessary to install steering cable
5. ☐ Cleaned and serviced steering/tilt tube
6. ☐ Lubricated engine end of steering cable
7. ☐ Removed and installed steering cable
8. ☐ Installed engine
9. ☐ Checked operation of steering system
10. ☐ Removed and replaced helm
11. ☐
12. ☐
13. ☐
14. ☐
15. ☐

COMPETENCY ACHIEVED? ☐ **YES** ☐ **NO**

EXPLANATION:

NAME________________________ **STUDENT NO.**________________________

18.01

PERFORMANCE CHECKLIST

MODULE : REPAIRING STEERING SYSTEM AND REMOTE CONTROLS

COMPETENCY: Troubleshoot and repair control boxes and control cables.

1. ☐ Recognized and named control box components
2. ☐ Removed control box from boat
3. ☐ Disconnected control box ends of cables
4. ☐ Disassembled control box
5. ☐ Cleaned and lubricated throttle and shift mechanisms
6. ☐ Installed control cables in control box
7. ☐ Assembled box and installed it on boat
8. ☐ Adjusted throttle cable
9. ☐ Adjusted shift cable
10. ☐ Checked operation of control box and cables
11. ☐
12. ☐
13. ☐
14. ☐
15. ☐

COMPETENCY ACHIEVED? ☐ **YES** ☐ **NO**

EXPLANATION:

UNIT 19 - RIGGING

MODULE 19.01

CHOOSING WIRE **INSTRUCTOR GUIDE**

COMPETENCY:
Select wire size according to repair or installation job requirements.

INSTRUCTIONAL OBJECTIVES:

The student will be able to:
1. Identify types of wire found in boats and on outboard engines.
2. State the characteristics of wire which affect its performance as a conductor.
3. State the name of the standard unit for indicating wire sizes.
4. Look up industry standards for the installation of wire.
5. Determine loading for small boat accessories.
6. Use a 10% wire chart to select appropriate wire sizes for installing boat and engine accessories.
7. Select wire colors according to the American Boat and Yacht Council standards.
8. Look up wire insulation codes.

LEARNING ACTIVITIES:
1. Participate in class lectures and discussions.
   (Objectives 1 - 8)
2. Read Chapter 3, "The Modern Boat's DC System" in Your Boat's Electrical System.
   (Objectives 2 - 8)
3. Read pages 41 through 47 in the NMMA Certification Handbook.
   (Objectives 4 - 7)

EVALUATION/CHECK-OUT:
You will be given opportunities to repair electrical systems and install electrical accessories on boats which have been brought into the shop. Your ability to select wire for these jobs will be evaluated and recorded on the performance checklist.

RESOURCES:

LEARNING MATERIALS:
1. Reference
   1986 NMMA Certification Handbook
   National Marine Manufacturer's Association
   401 North Michigan Avenue
   Chicago, IL 60611

2. Reference
   "Your Boat's Electrical System, 2nd Revised Edition
   Conrad Miller, Elbert S. Maloney
   1988, The Hearst Corporation
   ISBN 0-688-08132-0

MODULE 19.01

EQUIPMENT:

1. Student tool kits.
   (Refer to the Tools section of this document for specifications.)

2. Live work for students to practice boat wiring system troubleshooting/repair techniques and accessory installation. Try to plan ahead and arrange for boats to be brought into the shop.

AUDIO VISUAL MATERIALS:

(none used)

NAME__________________________ STUDENT NO.__________________________

19.01 **PERFORMANCE CHECKLIST**

MODULE : CHOOSING WIRE

COMPETENCY: Select wire size according to repair or installation job requirements.

1. ☐ Identified all accessories on circuit
2. ☐ Determined total current draw for accessories in circuit
3. ☐ Determined length of conductor required for circuit
4. ☐ Looked up appropriate wire size in 10% wire chart
5. ☐ Selected appropriate color wire for circuit
6. ☐
7. ☐
8. ☐
9. ☐
10. ☐
11. ☐
12. ☐
13. ☐
14. ☐
15. ☐

COMPETENCY ACHIEVED? ☐ YES ☐ NO

EXPLANATION:

MODULE 19.02

RIGGING BOAT ELECTRICAL ACCESSORIES **INSTRUCTOR GUIDE**

COMPETENCY:
Troubleshoot, repair, and install boat electrical components and accessories.

INSTRUCTIONAL OBJECTIVES:

The student will be able to:

1. Troubleshoot and repair boat wiring harness, fuse block & fuses, and ground block.
2. Troubleshoot, repair, and install gauges and indicators.
3. Troubleshoot, repair, and install navigation lights.
4. Troubleshoot, and install bilge ventilators/blowers.
5. Troubleshoot, and install bilge pumps.

LEARNING ACTIVITIES:

1. Participate in class lectures and discussions. (Objectives 1 - 9)
2. You will be given the opportunity to troubleshoot electrical systems and install electrical accessories on boats which have been brought into the shop for repairs. (Objectives 1 - 5)

EVALUATION/CHECK-OUT:
The instructor will evaluate your ability to troubleshoot and repair boat electrical systems and install electrical accessories as you practice your techniques on boats which have been brought into the shop. Your performance will be recorded on the performance checklist.

RESOURCES:

LEARNING MATERIALS:
(none used)

EQUIPMENT:

1. Student tool kit. (For specifications refer to the Tools section of this document)

2. Live work for students to practice troubleshooting and repair, and installation techniques. If live work will be used try to plan ahead and arrange for boats to be brought in.

AUDIO VISUAL MATERIALS:
(none used)

NAME____________________________ STUDENT NO.____________________________

19.02 **PERFORMANCE CHECKLIST** 1 of 2

MODULE : RIGGING BOAT ELECTRICAL ACCESSORIES

COMPETENCY: Troubleshoot, repair, and install boat electrical components and accessories.

1. ☐ Used test light to locate wiring harness trouble
2. ☐ Used ohmmeter to test fuses
3. ☐ Used crimp connectors to repair wiring harness
4. ☐ Repaired wiring harness using soldering techniques
5. ☐ Selected, removed, and replaced fuses
6. ☐ Used ohmmeter to test accessory switches
7. ☐ Removed and repalced accessory switches
8. ☐ Planned locations on dash for new gauges
9. ☐ Used template to draw gauge locations on dash
10. ☐ Selected hole saw and cut gauge holes in dash
11. ☐ Mounted gauges in dash
12. ☐ Connected gauge light
13. ☐ Connected gauge sender wire
14. ☐ Tested gauge function as listed in gauge specifications
15. ☐ Used test light to isolate navigation light trouble

COMPETENCY ACHIEVED? ☐ YES ☐ NO

EXPLANATION:

NAME____________________________ **STUDENT NO.**____________________________

19.02 **PERFORMANCE CHECKLIST** contd. 2 of 2

MODULE : RIGGING BOAT ELECTRICAL ACCESSORIES

COMPETENCY: Troubleshoot, repair, and install boat electrical components and accessories.

16. ☐ Used battery and jumpers to test navigation light bulbs
17. ☐ Selected, removed and installed navigation light bulbs
18. ☐ Selected, removed and installed navigation light fixture
19. ☐ Used test light to isolate bilge blower trouble
20. ☐ Selected, removed, and replaced bilge vent blower
21. ☐ Used test light to isolate bilge pump trouble
22. ☐ Selected, removed, and replaced bilge pump
23. ☐ Tested bilge pump operation by flooding boat bilge
24. ☐
25. ☐
26. ☐
27. ☐
28. ☐
29. ☐
30. ☐

COMPETENCY ACHIEVED? ☐ YES ☐ NO

EXPLANATION:

MODULE 19.03

RIGGING OUTBOARD ENGINES **INSTRUCTOR GUIDE**

COMPETENCY:
Install a single non-portable outboard engine and related components on a boat.

INSTRUCTIONAL OBJECTIVES:

The student will be able to:

1. Locate and draw a center line on a boat transom.
2. State the rule-of-thumb criterion for selecting engine installation height.
3. Install a drilling fixture to drill engine mounting bolt holes in a boat transom.
4. Select and apply sealer to engine mounting bolt holes.
5. Install engine on a boat transom using appropriate mounting hardware build-up and fastener torque.
6. Select a location for and install portable and permanent mount fuel tanks.
7. Select and install water separating fuel filters.
8. Select a location for and install remote oil tanks.
9. Select, choose a location for, and install cranking batteries.
10. Install dual batteries and battery switch or battery isolator.

LEARNING ACTIVITIES:

1. Participate in class lectures and discussions.
   (Objectives 1 - 10)
2. View the videotape "Safety and Rigging"
   (Objectives 1 - 5)
3. Read page 47 in the NMMA Certification Handbook.
   (Objective 9)
4. Locate a manufacturer's service manual for a non-portable outboard engine. Find and read the section in the manual which covers engine installation.
   (Objectives 1 - 5)
5. Practice your skills for engine installation on a boat which has been brought into the shop for that purpose. Since there will not be the opportunity for every student to install an engine, you will be assigned portions of the task as part of a group project. Be sure to devote your attention appropriately as other members of the group perform their assigned parts of the installation.
   (Objectives 1 - 10)

EVALUATION/CHECK-OUT:
The instructor will observe you as you practice your engine installation skills on a boat which has been brought into the shop for that purpose. You may not get to practice every part of an engine installation so you will be quizzed verbally on the portions of the task which you don't get

to perform. Your performance will be recorded on the performance checklist.

RESOURCES:

LEARNING MATERIALS:

1. Reference
   NMMA Certification Handbook
   National Marine Manufacturers Association
   401 North Michigan Avenue
   Chicago, IL 60611

2. Reference
   Manufacturer's service manuals

EQUIPMENT:

1. Student tool kit.
2. Engine crane or hoist.
3. Transom drilling fixture.
4. Drill motor, 1/2", with bits
5. Boat, boxed engine, and accessories necessary for installation. Pre-planning will be necessary to arrange for this items

AUDIO VISUAL MATERIALS:

1. Videotape
   "Safety and Rigging"
   OMC P/N VT7980B
   OMC Training Department, Desk C-613
   3145 Central Avenue
   Waukegan, IL 60085
   (312) 689-5531

NAME________________________ STUDENT NO.________________________

19.03 **PERFORMANCE CHECKLIST** 1 of 2

MODULE : RIGGING OUTBOARD ENGINES

COMPETENCY: Install a single non-portable outboard engine and related components on a boat.

1. ☐ Located and marked boat transom centerline
2. ☐ Installed transom drilling fixture
3. ☐ Selected drill bit and drilled engine mounting holes
4. ☐ Unpacked engine and prepared it for installation
5. ☐ Laid out mounting hardware
6. ☐ Selected and applied sealer to mounting holes
7. ☐ Pre-routed steering cable as required
8. ☐ Mounted engine on transom at appropriate height
9. ☐ Used correct mounting hardware build-up
10. ☐ Torqued mounting fasteners to specification
11. ☐ Attached steering components
12. ☐ Mounted remote oil tank in appropriate location
13. ☐ Routed and secured oil line
14. ☐ Mounted permanent fuel tank according to NMMA specs.
15. ☐ Installed water separating fuel filter

COMPETENCY ACHIEVED? ☐ YES ☐ NO

EXPLANATION:

NAME______________________________ **STUDENT NO.**______________________________

19.03 **PERFORMANCE CHECKLIST** contd. **2 of 2**

MODULE : RIGGING OUTBOARD ENGINES

COMPETENCY: Install a single non-portable outboard engine and related components on a boat.

16. ☐ Selected appropriate fuel line
17. ☐ Routed and secured fuel line
18. ☐ Selected battery according to boat/engine requirements
19. ☐ Mounted battery according to NMMA specifications
20. ☐ Installed dual batteries according to NMMA specs.
21. ☐ Installed battery switch
22. ☐ Installed battery isolator
23. ☐
24. ☐
25. ☐
26. ☐
27. ☐
28. ☐
29. ☐
30. ☐

COMPETENCY ACHIEVED? ☐ **YES** ☐ **NO**

EXPLANATION:

MODULE 19.04

SELECTING PROPELLERS **INSTRUCTOR GUIDE**

COMPETENCY:
Select outboard engine propellers to obtain optimum boat performance.

INSTRUCTIONAL OBJECTIVES:

The student will be able to:
1. Recognize and name the parts of a propeller.
2. Describe the materials commonly used in the manufacture of propellers.
3. Explain how propellers work.
4. Differentiate propeller cavitation and ventilation.
5. Explain the meaning of the term "gearcase blowout".
6. Select propellers using manufacturer's propeller charts.
7. Use "propping out" techniques to select the motor height and propeller combination which will optimize the performance of a boat.

LEARNING ACTIVITIES:
1. Participate in class lectures and discussions.
   (Objectives 1 - 7)
2. Read "Everything You Need To Know About Propellers"
   (Objectives 1 - 7)
3. View the videotapes "Propping Out" and "The Makings of an SST Propeller".
   (Objectives 1, 2, 7)
4. Practice using propeller charts. Obtain a copy of a manufacturer's propeller chart. Go into the shop and make a list of the types of boats that you find there noting their size and what you think they are used for. Also note the size engine on each. Look up the manufacturer's propeller recommendation for each and compare it with the propeller already on the engine.
   (Objective 6)

5. Practice your propping out techniques on the shop boat.
   (Objective 7)

EVALUATION/CHECK-OUT:
1. Take the "Propellers" multiple choice test and score 70% or better.

2. The instructor will ask you to recommend propellers for boats that come into the shop. Your ability to do so will be recorded on the performance checklist.

3. The instructor will check your ability to prop out a boat by observing you as you prop out the shop boat. Your performance will be recorded on the performance checklist.

MODULE 19.04

RESOURCES:

LEARNING MATERIALS:

1. Reference
   Copies of manufacturer's propeller charts

2. Reference
   "Everything You Need To Know About Propellers",
   Third Edition, P/N 90-86144
   Mercury Marine
   Fond du Lac, WI 54935
   (This a very good reference. You should consider purchasing one copy per student.)

EQUIPMENT:

A boat, (14 - 19 runabout), rigged with an appropriate outboard engine, power trim, adjustable jackplate and a selection of propellers. This rig will be used to teach propping out techniques.

AUDIO VISUAL MATERIALS:

1. Videotape
   "Propping Out"
   P/N VT7820B
   OMC Training Department
   3145 Central Avenue, Desk-613
   Waukegan, IL 60085
   (312) 689-5531

2. "The Makings of an SST Propeller"
   P/N 76402
   OMC Training Department
   3145 Central Avenue, Desk-613
   Waukegan, IL 60085
   (312) 689-5531

MODULE 19.04

Propellers Multiple Choice Test

NAME________________________________ STUDENT NO.________________

1. The side of a propeller blade facing toward the bow of the boat is the

   a. trailing edge
   b. blade back
   c. leading edge
   d. blade face

2. The side of a propeller blade pointing back away from the boat is the

   a. trailing edge
   b. blade back
   c. leading edge
   d. blade face

3. The purpose of the inner rubber hub on propellers is to

   a. ease propeller construction
   b. allow slippage if an underwater object is struck
   c. dampen vibration
   d. allow different props to be attached to same propshaft

4. Blade cup is

   a. the part that attaches the blade to the hub
   b. the part of the prop pitching tool used to hold the blade
   c. extra curvature added to prop trailing edge
   d. found around outer hub to diffuse exhaust gas

5. The most common direction of outboard engine propeller rotation is

   a. counter-clockwise
   b. clockwise

6. Propeller blade pitch is

   a. a protective coating to prevent corrosion
   b. figured by measuring the surface area of the blade
   c. the theoretical distance that a propeller would move

in one revolution
d. the angle that the blade makes with the outer hub

7. Propeller blade rake is

    a. a projection from the outer hub used to cut weeds
    b. the curvature of a prop blade cross-section
    c. the theoretical distance that a propeller would move in one revolution
    d. the angle that the blade makes with the outer hub

8. Propeller diameter is

    a. the width of the circle traced by spinning the prop blades.
    b. the width of the outer hub
    c. the width of the largest circle which can be drawn on the face of a prop blade.
    d. not really a factor when choosing outboard propellers

9. When a very low pressure situation happens on the negative-side of the propeller blade and causes water vapor bubbles to occur the prop is said to be

    a. ventilating
    b. cavitating
    c. progressively pitched
    d. over raked

10. When the propeller begins to suck air from the water's surface it is said to be

    a. ventilating
    b. cavitating
    c. progressively pitched
    d. over raked

11. The water vapor bubbles caused when a propeller is cavitating condense on the blade face. This process usually

    a. can lead to the wearing away of the blade surface
    b. has little effect on the prop or its performance
    c. causes gearcase blowout
    d. happens at low RPM

12. Propeller ventilation

    a. can cause steering torque
    b. causes "paddle wheeling"
    c. can be used to improve out-of-the-hole performance

d. is prevented by the AV plate when the engine is mounted at higher than standard locations

13. Steering torque is caused by

    a. ventilation
    b. cavitation
    c. paddle wheeling
    d. excessive boat speed

14. Stainless steel propellers provide increased ___________ when compared with aluminum propellers of the same pitch and diameter

    a. durability
    b. boat speed
    c. fuel economy
    d. gearcase life

15. The most important consideration when choosing a propeller for a particular boat is

    a. engine size
    b. combined weight to boat and load
    c. boat speed
    d. fuel economy

MODULE 19.04

Propellers Multiple Choice Test

ANSWER KEY

1. B
2. D
3. B
4. C
5. B
6. C
7. D
8. A
9. B
10. A
11. A
12. C
13. C
14. A
15. B

NAME________________________ STUDENT NO.________________________

19.04 **PERFORMANCE CHECKLIST**

MODULE : SELECTING PROPELLERS

COMPETENCY: Select outboard engine propellers to obtain optimum boat performance.

1. ☐ Took test
2. ☐ Score
3. ☐ Made propeller recommendations using prop chart
4. ☐ Selected tools required for propping out session
5. ☐ Selected range of propellers for propping out
6. ☐ Made up propping out form
7. ☐ Looked up engine RPM recommendation
8. ☐ Tested prop and engine height combinations
9. ☐ Recorded test results on form
10. ☐ Made propeller recommendation based on test results
11. ☐
12. ☐
13. ☐
14. ☐
15. ☐

COMPETENCY ACHIEVED? ☐ **YES** ☐ **NO**

EXPLANATION:

MODULE 19.05

RIGGING BOAT ACCESSORIES	INSTRUCTOR GUIDE

COMPETENCY:
Install accessories which mount on boat deck, hull, or transom.

INSTRUCTIONAL OBJECTIVES:

The student will be able to:
1. Select and apply sealer as required for accessory installation.
2. Install bow and transom rails.
3. Install swim platforms.
4. Install cleats and bow eyes.
5. Install through-the-hull fittings.
6. Install bracket for auxiliary motor.
7. Select mounting hardware as required for accessory installation.
8. Determine the need for strain reliefs during accessory installation.
9. Fabricate and install strain reliefs.

LEARNING ACTIVITIES:
1. Participate in class lectures and discussions. (Objectives 1 - 9)
2. Practice installing accessories on boats which have been brought into the shop for that purpose.

EVALUATION/CHECK-OUT:
The instructor will observe you as you practice your boat accessory installation skills on a boat which has been brought into the shop for that purpose. You may not get to practice installing every type of accessory so you will be quizzed verbally on the types of installation which you don't get to perform. Your performance will be recorded on the performance checklist.

RESOURCES:

LEARNING MATERIALS:
(none used)

EQUIPMENT:
1. Student tool kits.
2. Boats which require accessory installation. Plan ahead to have live work brought into the shop.

AUDIO VISUAL MATERIALS:
(none used)

NAME____________________________ STUDENT NO.____________________________

19.05

PERFORMANCE CHECKLIST

MODULE : RIGGING BOAT ACCESSORIES

COMPETENCY: Install accessories which mount on boat deck, hull or transom.

1. ☐ Selected and applied sealer for accessory installation
2. ☐ Selected accessory mounting hardware
3. ☐ Fabricated and installed strain reliefs as required
4. ☐ Installed bow eye
5. ☐ Installed cleats
6. ☐ Installed swim platform
7. ☐ Installed through-the-hull fittings
8. ☐ Installed bow/transom rails
9. ☐ Installed mount for auxiliary outboard motor
10. ☐
11. ☐
12. ☐
13. ☐
14. ☐
15. ☐

COMPETENCY ACHIEVED? ☐ YES ☐ NO

EXPLANATION:

MODULE 19.06

RIGGING TRAILERS	INSTRUCTOR GUIDE

COMPETENCY:
1. Adjust boat and trailer combination for best towing performance.
2. Repair trailer boat bunks/rollers and adjust trailer to boat.
3. Repair and maintain trailer wheels and axles.
4. Repair and install trailer lights.
5. Install trailer accessories.

INSTRUCTIONAL OBJECTIVES:

The student will be able to:
1. Recognize and name the parts of a trailer.
2. Locate and interpret trailer certification plates and identify trailer towing class.
3. Recognize and name types of trailer hitches.
4. Select and install hitch balls based on towing class requirements.
5. Recognize and name trailer brake systems.
6. Adjust a trailer to fit a boat.
7. Adjust trailer axle position for best towing performance.
8. Recognize and name the parts of a trailer axle and wheel assembly.
9. Select trailer tires according to load requirements.
10. Inflate trailer tires for best performance
11. Disassemble, inspect, repair, and lubricate trailer wheel bearings.
12. Troubleshoot, repair, and install trailer lights
13. Install electric and manual winches.
14. Install a spare tire carrier.
15. Install Bearing Buddies.
16. Install a trailer tongue dolly.
17. Install boat tie downs.
18. Install a transom saver.
19. Remove and replace trailer bunks and rollers.

LEARNING ACTIVITIES:
1. Participate in class lectures and discussions.
   (Objectives 1 - 19)

2. Read pages 56 - 66 in the NMMA Certification Handbook.
   (Objectives 2, 4, 12, 13)

3. Observe the following demonstrations:
   Adjusting Trailers To Boats
   Adjusting Trailers For Best Towing Performance
   Wheel Bearing Removal, Packing, and Installation
   (Objectives 1, 6 - 8, 11, 15)

4. As boats are brought into the shop locate their trailer certification

plates. Read the certification plates and compare the numbers you find with the boat's weight loaded and unloaded. Observe the suspension system on the trailers and note the various types that you find. Also note the rigging location and method of trailer accessories
(Objectives 1 - 3, 5, 13 - 18)

EVALUATION/CHECK-OUT:
You will be given the opportunity to adjust trailers, repair wheel bearings, repair/install lights, and install accessories on trailers which have been brought into the shop. Your ability to perform these tasks will be evaluated and your performance recorded on the performance checklist.

RESOURCES:

LEARNING MATERIALS:

1. Reference

   1986 NMMA Certification Handbook
   National Marine Manufacturer's Association
   401 North Michigan Avenue
   Chicago, IL 60611

EQUIPMENT:

1. Lifting equipment:
   - Trailer jacks
   - Jack stands
   - Wheel chocks
   - Boat Hoist
2. Bearing race driver set
3. Student tool kit
4. Trailers to be provided as live work. Plan ahead to have trailers brought in for repair work or the installation of accessories.

AUDIO VISUAL MATERIALS:
(none used)

NAME______________________________ STUDENT NO.______________________________

19.06 **PERFORMANCE CHECKLIST**

MODULE : RIGGING TRAILERS

COMPETENCY: Adjust boat and trailer rig for best towing performance.

1. ☐ Recognized and named trailer parts
2. ☐ Located trailer certification plate
3. ☐ Checked certification information against rig weight
4. ☐ Determined direction to move axle to improve handling
5. ☐ Hooked rig to towing vehicle
6. ☐ Loosened axle mounting hardware
7. ☐ Chocked trailer wheels
8. ☐ Used towing vehicle to slide trailer frame on axle assy.
9. ☐ Checked axle for squareness with trailer frame
10. ☐ Tightened axle mounting hardware
11. ☐ Road tested rig
12. ☐
13. ☐
14. ☐
15. ☐

COMPETENCY ACHIEVED? ☐ YES ☐ NO

EXPLANATION:

NAME______________________________ STUDENT NO.______________________________

19.06

PERFORMANCE CHECKLIST

MODULE : RIGGING TRAILERS

COMPETENCY: Repair boat bunks/rollers and adjust trailer to boat.

1. ☐ Removed boat from trailer
2. ☐ Examined bunks for rot and/or damage
3. ☐ Examined rollers for defects
4. ☐ Detected rotten or damaged bunks
5. ☐ Detected defective rollers
6. ☐ Fabricated new bunks using old ones as pattern
7. ☐ Installed carpet on bunks
8. ☐ Installed bunks
9. ☐ Removed and replaced rollers
10. ☐ Adjusted bunks and rollers to boat hull
11. ☐ Loaded boat onto trailer
12. ☐
13. ☐
14. ☐
15. ☐

COMPETENCY ACHIEVED? ☐ YES ☐ NO

EXPLANATION:

NAME____________________________ STUDENT NO.____________________________

19.06

PERFORMANCE CHECKLIST

MODULE : RIGGING TRAILERS

COMPETENCY: Repair and maintain trailer wheels and axles.

1. ☐ Chocked trailer wheel or hooked to towing vehicle
2. ☐ Used floor jack to raise wheel to be repaired
3. ☐ Installed jack stand(s)
4. ☐ Removed wheel
5. ☐ Cleaned and inspected hub, spindle, and bearing parts
6. ☐ Removed bearing from spindle
7. ☐ Removed bearing race from hub
8. ☐ Packed bearing with grease
9. ☐ Installed bearing on spindle
10. ☐ Used cup driver to install bearing race in hub
11. ☐ Installed tire/wheel assembly
12. ☐ Adjusted axle nut for appropriate wheel free-play
13. ☐ Inflated tires to required pressure
14. ☐ Let trailer down off jack stands
15. ☐

COMPETENCY ACHIEVED? ☐ **YES** ☐ **NO**

EXPLANATION:

NAME________________________ STUDENT NO.________________________

19.06

PERFORMANCE CHECKLIST

MODULE : RIGGING TRAILERS

COMPETENCY: Repair and maintain trailer lights.

1. ☐ Removed and tested light bulbs
2. ☐ Selected and installed trailer light bulbs
3. ☐ Used test equipment to isolate wiring harness trouble
4. ☐ Removed and replaced trailer-side pigtail connector
5. ☐ Removed and replaced trailer wiring harness
6. ☐ Removed and replaced trailer tail and marker lights
7. ☐
8. ☐
9. ☐
10. ☐
11. ☐
12. ☐
13. ☐
14. ☐
15. ☐

COMPETENCY ACHIEVED? ☐ YES ☐ NO

EXPLANATION:

NAME________________________ STUDENT NO.________________________

19.06 **PERFORMANCE CHECKLIST**

MODULE : RIGGING TRAILERS

COMPETENCY: Install trailer accessories.

1. ☐ Removed damaged winch cables
2. ☐ Selected and installed new winch cables
3. ☐ Selected and installed a manual winch
4. ☐ Installed electric winch on trailer
5. ☐ Installed towing vehicle wiring for electric winch
6. ☐ Installed trailer wheel Bearing Buddies
7. ☐ Filled Bearing Buddies with grease
8. ☐ Installed spare tire carrier on trailer
9. ☐ Installed boat tie downs
10. ☐ Installed Transom Saver
11. ☐ Selected and installed tongue dolly
12. ☐
13. ☐
14. ☐
15. ☐

COMPETENCY ACHIEVED? ☐ **YES** ☐ **NO**

EXPLANATION:

UNIT 20 -
JOB SEEKING SKILLS

MODULE 20.01

PREPARING FOR THE JOB SEARCH	INSTRUCTOR GUIDE

This module is taken verbatim from module #1, pg. 7, in the instructional manual "Job Seeking Skills" produced by Moraine Park Technical College. A copy of this instructional manual is included with Unit 20.

This module is not intended to replace curriculum that may already be installed in your program but serves to act as a model for a minimum standard.

COMPETENCY:

Identify those tools you need to find a job and utilize the most effective methods for identifying prospective employers.

INSTRUCTIONAL OBJECTIVES:

The student will be able to:

1. Identify four main reasons for prolonged unemployment.
2. Describe five myths people typically believe about finding work.
3. Identify the tools you need to find a job.
4. Describe the process of job hunting.
5. Describe which methods of job hunting are statistically most likely to produce results.
6. Evaluate the wisdom of this statement: "The two most powerful tools for finding work are the telephone and the Yellow Pages".
7. Identify five sources of employer information.
8. Use a minimum of three different sources to identify prospective employers.
9. Inquire about employment possibilities in an area outside your county.

LEARNING ACTIVITIES:

See module #1, pg. 7, in "Job Seeking Skills".

EVALUATION/CHECK-OUT:

Turn in the worksheets you developed for the performance tasks.

RESOURCES:

LEARNING MATERIALS:

See module #1, pg. 7, in "Job Seeking Skills".

EQUIPMENT:

(none required)

AUDIO VISUAL MATERIALS:

MODULE 20.01

See "Job Seeking Skills", module #1, pg. 7.

NAME______________________ STUDENT NO.______________________

20.01 **PERFORMANCE CHECKLIST**

MODULE : PREPARING FOR THE JOB SEARCH

COMPETENCY: Identify those tools you need to find a job and utilize the most effective methods for identifying prospective employers.

1. ☐ Turned in prospective employer list
2. ☐ Turned in sample letter of inquiry
3. ☐ Turned in Job Service worksheet
4. ☐
5. ☐
6. ☐
7. ☐
8. ☐
9. ☐
10. ☐
11. ☐
12. ☐
13. ☐
14. ☐

COMPETENCY ACHIEVED? ☐ **YES** ☐ **NO**

EXPLANATION:

MODULE 20.02

RESUMES, JOB APPLICATIONS, AND LETTERS OF APPLICATION **INSTRUCTOR GUIDE**

This module is taken verbatim from module #2, pg. 15, in the instructional manual "Job Seeking Skills" produced by Moraine Park Technical College. A copy of this instructional manual is included with Unit 20.

This module is not intended to replace curriculum that may already be installed in your program but serves to act as a model for a minimum standard.

COMPETENCY:

Apply written communication skills to prepare a resume, professional profile, job application, and appropriate cover letters.

INSTRUCTIONAL OBJECTIVES:

The student will be able to:

1. List six reasons why resumes are written.
2. Explain why merely mailing out resumes is ineffective in finding work.
3. Identify the categories of a resume.
4. Explain why information such as age, height, weight, marital status, and sex would generally not be included in a resume.
5. Identify your achievement and skills.
6. Compose an achievement oriented, ready-to-mail resume.
7. Describe how you might forego the application-filling process altogether.
8. Prepare a professional profile to be used for reference when completing job applications.
9. Neatly and thoroughly complete job applications.
10. Differentiate between a letter of application and a resume.
11. Identify the organization of a letter of application.
12. Write resume cover letters.
13. Describe how you would use cover materials to mail a resume.

LEARNING ACTIVITIES:

See module #2, pg. 15, in "Job Seeking Skills".

EVALUATION/CHECK-OUT:

Turn in the worksheets you developed for the performance tasks described in module #2.

RESOURCES:

LEARNING MATERIALS:

MODULE 20.02

See module #2, pg. 15, in "Job Seeking Skills".

EQUIPMENT:
(none required)

AUDIO VISUAL MATERIALS:

See module #2, pg. 15, in "Job Seeking Skills".

NAME__________________________ STUDENT NO.__________________________

20.02 PERFORMANCE CHECKLIST

MODULE : RESUMES, JOB APPLICATIONS, AND LETTERS OF APPLICATION

COMPETENCY: Apply written communication skills to prepare a resume, job application, and appropriate cover letters.

1. ☐ Turned in sample results list and draft resume
2. ☐ Turned in ready-to-mail resume
3. ☐ Resume passed criteria on resume evaluation sheet
4. ☐ Developed a personal professional profile
5. ☐ Filled out sample job application
6. ☐ Sample job application passed criteria on eval. sheet
7. ☐ Wrote cover letters
8. ☐ Cover letters passed criteria on evaluation sheet
9. ☐
10. ☐
11. ☐
12. ☐
13. ☐
14. ☐

COMPETENCY ACHIEVED? ☐ **YES** ☐ **NO**

EXPLANATION:

MODULE 20.03

INTERVIEWING FOR A JOB **INSTRUCTOR GUIDE**

This module is taken verbatim from module #3, pg. 42, in the instructional manual "Job Seeking Skills" produced by Moraine Park Technical College. A copy of this instructional manual is included with Unit 20.

This module is not intended to replace curriculum that may already be installed in your program but serves to act as a model for a minimum standard.

COMPETENCY:

Use effective communication skills in a job interview.

INSTRUCTIONAL OBJECTIVES:

The student will be able to:

1. Identify employer's three major expectations of employees.
2. Effectively present personal assets, skills, and related experiences during a job interview.
3. Determine the image you would like to present during an interview.
4. Present a positive and competent image through effective non-verbal communication.
5. Prepare answers for probable questions in a job interview.
6. Effectively and positively handle unlawful or difficult questions in a job interview.
7. Prepare questions to ask the interviewer during the interviewer during the interview.
8. Identify the tools you could use to research a company before an interview.
9. Explain the steps you must take to prepare for an interview.
10. Explain why bringing up wage and benefit questions during a first interview could work against you.
11. List the responsibilities of the interviewee and interviewer in a job interview.
12. Describe the four basic parts of an employer telephone contact.
13. Distinguish between an informational and employment interview.
14. Describe the two follow-up methods you could use.

LEARNING ACTIVITIES:

See module #3, pg. 42, in "Job Seeking Skills".

EVALUATION/CHECK-OUT:

Turn in the worksheets you developed for the performance tasks.

RESOURCES:

MODULE 20.03

LEARNING MATERIALS:
See module #3, pg. 42, in "Job Seeking Skills".

EQUIPMENT:
(none required)

AUDIO VISUAL MATERIALS:

See "Job Seeking Skills", module #3, pg. 42.

NAME ______________________ STUDENT NO. ______________________

20.03 **PERFORMANCE CHECKLIST**

MODULE : INTERVIEWING FOR A JOB

COMPETENCY: Use effective communication skills in a job interview.

1. ☐ Turned in Expectations worksheet
2. ☐ Summarized personal attributes orally to class
3. ☐ Attended mock job interview
4. ☐ Passed criteria on interview evaluation sheet
5. ☐ Turned in interview follow-up letter
6. ☐ Turned in written phone contact
7. ☐ Made "cold" phone contact with employer
8. ☐ Conducted informational interview
9. ☐ Turned in informational interview evaluation sheet
10. ☐
11. ☐
12. ☐
13. ☐
14. ☐
15. ☐

COMPETENCY ACHIEVED? ☐ **YES** ☐ **NO**

EXPLANATION:

MODULE 20.04

MAPPING YOUR JOB HUNTING PLANS INSTRUCTOR GUIDE

This module is taken verbatim from module #4, pg. 70, in the instructional manual "Job Seeking Skills" produced by Moraine Park Technical College. A copy of this instructional manual is included with Unit 20.

This module is not intended to replace curriculum that may already be installed in your program but serves to act as a model for a minimum standard.

COMPETENCY:

Develop a specific map for job hunting.

INSTRUCTIONAL OBJECTIVES:

The student will be able to:
1. Identify the most effective methods for job hunting.
2. Describe the concept of networking.
3. Determine the number of hours per week you will need to spend on the various types of job hunting methods.
4. Develop a sample daily job search plan.
5. Develop a mechanism for keepin track of employer contacts.

LEARNING ACTIVITIES:

See module #4, pg. 70, in "Job Seeking Skills".

EVALUATION/CHECK-OUT:

Turn in the worksheets you developed for the performance tasks.

RESOURCES:

LEARNING MATERIALS:
See module #4, pg. 70, in "Job Seeking Skills".

EQUIPMENT:
(none required)

AUDIO VISUAL MATERIALS:

See "Job Seeking Skills", module #4, pg. 70.

NAME____________________________ **STUDENT NO.**____________________________

20.04 **PERFORMANCE CHECKLIST**

MODULE : MAPPING YOUR JOB HUNTING PLANS

COMPETENCY: Develop a specific map for job hunting.

1. ☐ Turned in sample job hunting plan
2. ☐ Turned in sample follow-up sheet
3. ☐ Turn in sample tracking calendar
4. ☐
5. ☐
6. ☐
7. ☐
8. ☐
9. ☐
10. ☐
11. ☐
12. ☐
13. ☐
14. ☐
15. ☐

COMPETENCY ACHIEVED? ☐ **YES** ☐ **NO**

EXPLANATION:

Appendix 16

END

U.S. Dept. of Education

Office of Education
Research and
Improvement (OERI)

ERIC

Date Filmed

March 29, 1991